**THE INFLUENCE OF CLIMATE CHANGE ON THE VALUE OF COASTAL RESIDENTIAL PROPERTIES IN SOUTH AFRICA**

by

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# DECLARATION

I certify that the *thesis* submitted by me for the degree *Philosophiae Doctor (Finance)* at the University of Johannesburg is my independent work and has not been submitted by me for a degree at another university.

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André Kruger



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Date

# DEDICATION

**To Mandi**

My beloved wife, without you this journey would not have been possible nor accomplished.

ACKNOWLEDGEMENTS

'I am in competition with no one. I run my own race. I have no desire to play the game of being better than anyone. I just aim to improve, to be better than I was before. That's me, and I'm free.' Jenny G Perry

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# ABSTRACT

In March 2007, the KwaZulu-Natal coast was hit by storm swells which severely damaged coastal properties. The economic loss was estimated to be more than R1 billion. Risk associated with the changing climate is on the increase and if the number of studies (nationally and globally) regarding this phenomenon are considered, there is a need to quantify this risk. This raises questions regarding property valuers' knowledge, behaviour and attitudes regarding climate change and their impact on the well-established property valuation processes and procedures in South Africa. In national and global studies, a variety of concepts, unrelated to market value or a manipulated form of market value, are used to quantify economic loss. However, financial decisions regarding property, plant and equipment are made based on the concept of market value. This presents the question this study attempts to answer: How does the predicted rise in sea level and its ensuing risk affect property valuers' behaviour in the coastal residential real estate market in Sedgefield, South Africa and how can property valuers quantify the climate risk? This study aimed to identify the knowledge, behaviour and attitudes of property valuers in a particular property market, on the southern Cape coast of South Africa, regarding the predicted rise in sea level. A mixed methods research approach by way of a two-stage sequential exploratory design, beginning with an initial phase of qualitative data collection and analysis, followed by a phase of quantitative data collection and analysis was followed. This provided the researcher with an opportunity to collect, analyse and incorporate qualitative and quantitative data in one study. The results was used to develop a model property valuers can use to determine a risk factor when they develop an opinion of the value of coastal residential properties. In this study a mixed methods approach was pursued. The southern Cape coast was chosen as two separate studies conducted in 1993 and 2010 identified it as the stretch of coastline along the South African coast most vulnerable to a rise in sea level.

**Keywords:** climate change, coastal property, immovable property, market value, residential property, rising sea level, risk

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# GLOSSARY

**Assessment report**: A series of reports produced by the Intergovernmental Panel on Climate Change (IPCC) to '*assess scientific, technical and socio-economic information concerning climate change, its potential effects and options for adaptation and mitigation*' (IPCC website, retrieved 4 May 2018).

**Assessed value**: '*a form of depreciated valuation, which captures the remaining economic life and value of a good, at the time it is damaged. This is not only a function of age, but also character and condition of assets*' (King, McGregor & Whittet, 2010:28).

**At-risk properties**: Properties at risk of being inundated by the rising sea level at a future date.

**Climate change:** '*a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity*' (United Nations Framework Convention on Climate Change (UNFCCC), 2011:1).

**Coastal management line (CML):** '*a line determined by an MEC in accordance with section 25 in order to demarcate an area within which development will be prohibited or controlled in order to achieve the objects of this Act or coastal management objectives*' (South Africa, 2014a:4)

**Coastal property:** Immovable property located within the coastal zone.

**Coastal zone:** '*the area comprising coastal public property, the coastal protection zone, coastal access land, coastal protected areas, the seashore and coastal waters and includes any aspect of the environment on, in, under and above such area*' (South Africa, 2014a:6).

**Consequential risk:** *'The risk of a consequential financial loss. 2. The risk of a secondary or further adverse event, following and caused by an initial one. For example the risk of a tsunami following - and caused by - an initial earthquake'* (Association of Corporate Treasurers, 2014).

**Development:** '*any process initiated by a person to change the use, physical nature or appearance of that place, and includes—*

*(a) the construction, erection, alteration, demolition or removal of a structure or building;*

*(b) a process to rezone, subdivide or consolidate land;*

*(c) changes to the existing or natural topography of the coastal zone; and*

*(d) the destruction or removal of indigenous or protected vegetation*' (South Africa, 2008:18)

**Environmental risk:** Sea level rise risk to coastal residential property because of beach erosion, flooding and inundation, saltwater intrusion, elevated coastal groundwater tables and storm damage.

**Estuary:** *'a body of surface water—*

*(a) that is permanently or periodically open to the sea;*

*(b) in which a rise and fall of the water level as a result of the tides is measurable at spring tides when the body of surface water is open to the sea; or*

*(c) in respect of which the salinity is higher than fresh water as a result of the influence of the sea, and where there is a salinity gradient between the tidal reach and the mouth of the body of surface water*' (South Africa, 2014a:6).

**Exploratory research**: "*a methodological approach that is primarily concerned with discovery and with generating or building theory*" (Jupp, 2006:110).

**Exploratory sequential mixed methods**: '*a design in which the researcher first begins by exploring with qualitative data and analysis and then uses the findings in a second quantitative phase*' (Creswell, 2014:267).

**High-water mark:** '*the highest line reached by coastal waters, but excluding any line reached as a result of—*

*(a) exceptional or abnormal floods or storms that occur no more than once in ten years; or*

*(b) an estuary being closed to the sea*' (South Africa, 2008:20)

**Holistic coding:** '*an attempt to "grasp basic themes or issues in the data by absorbing them as a whole … rather than by analysing them line by line" (Dey, 1993:104)*' (Saldaña, 2012:118).

**Immovable property:** a '*land unit'* which is '*a cadastral entity'* which can be registered in terms of the Deeds Registries Act 47 of 1937 (South Africa, 2014b:6).

**Intergovernmental Panel on Climate Change (IPCC)**: An intergovernmental scientific body created to provide an objective view of the changing climate and its impact (IPCC, 2013).

**International Valuation Standards (IVSs):** A set of independent global standards compiled by the International Valuation Standards Committee (IVSC) for valuation practice and the valuation profession (IVSC, 2017).

**Knysna strategic environmental assessment:** Guides the development planning and management of Knysna in a coordinated and integrated manner for the long term (Knysna Municipality, 2015).

**Land value:** The value of vacant or raw land (Appraisal Institute, 2009:359).

**Market value:** *'the estimated amount for which an asset or liability should exchange on the valuation date between a willing buyer and a willing seller in an arm's length transaction, after proper marketing and where the parties had each acted knowledgeably, prudently and without compulsion*' (IVSC, 2013:5).



**National Environmental Management: Integrated Coastal Management Amendment (ICM) Act 36 of 2014**: To govern the *'conservation of the coastal environment, and maintain the natural attributes of coastal landscapes and seascapes, and to ensure that development and the use of natural resources within the coastal zone is socially and economically justifiable and ecologically sustainable*' (South Africa, 2014a).

**Phenomenological research:** Describes the lived experience of the participants in a study (Maypole & Davies, 2001; Robinson & Reed, 1998; Greene, 1997).

**Phenomenology:** Investigates an event such as the changing climate from an individual's point of view (Lester, 1999).

**Pragmatic worldview**: According to Creswell (2014), pragmatism is concerned with situations, actions and consequences, as opposed to post-positivism which identifies and determines the reasons that affect results.

**Property valuer**: The term "property valuer" as used in South Africa is used in the thesis. The term "appraiser" is used in the USA.

**Property valuer's paradigm:** Achour-Fischer (2000) uses Kuhn's phrasing to describe the valuer's paradigm as a *'set of tools, methodologies, techniques, jargon and savoir-faire that … unify … theory and professional practices*'.

**Replacement cost:** '*the estimated cost to construct, at current prices as of the effective appraisal date, a substitute for the building being appraised using modern materials and current standards, design, and layout'* (Appraisal Institute, 2013:385).

**Residential property:** The single residential zoning in the study area which allows dwellings only (Knysna, 1992).

**Rising sea level:** The projected rise in sea level due to thermal expansion of the oceans and the melting of land-based ice (IPCC, 2007).

**Sales comparison approach:** '*the process of deriving a value indication for the subject property by comparing similar properties that have recently sold with the property being appraised, identifying appropriate units of comparison and making* *adjustments to the sale prices … of the comparable properties based on relevant, market-derived elements of comparison*' (Appraisal Institute, 2014:297).

**Sea:** '*all marine waters, including -*

*(a) the high seas;*

*(b) all coastal waters; and*

*(c) land regularly or permanently submerged by sea water, including—*

*(i) the bed, subsoil and substrata beneath those waters; and*

*(ii) land flooded by sea water which subsequently becomes part of*

*the bed of coastal waters, including the substrata beneath such land';* (South Africa, 2008)

**Valuation:** '*The act or process of developing an opinion of value';* in the USA this is referred to as an appraisal (Appraisal Institute, 2013:2).

# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| amsl | Above mean sea level |
| CML | Coastal management line |
| CPI | Consumer Price Index |
| CSIR | Council for Scientific and Industrial Research |
| DM | District Municipality |
| EIA | Environmental impact assessment |
| EPA | Environmental Protection Agency |
| GHGs | Greenhouse gases |
| GIS | Geographic information system |
| HBU | Highest and best use |
| ICM Act | National Environmental Management: Integrated Coastal Management Act |
| IPCC | Intergovernmental Panel on Climate Change |
| IVSs | International Valuation Standards |
| IVSC | International Valuation Standards Committee |
| LIDAR | Light Detection and Ranging |
| LM | Local Municipality |
| MEC | Member of the Executive Council |
| MPRA | Local Government: Municipal Property Rates Act |
| NASA | National Aeronautics and Space Administration |
| NEMA | National Environmental Management Act |
| NOAA | National Oceanic and Atmospheric Administration |
| RCPs | Representative concentration pathways |
| RICS | Royal Institute of Chartered Surveyors |
| SA | South Africa |
| SACPVP | South African Council for the Property Valuers Profession |
| SAPTG | South African Property Transfer Guide |
| SARVA | South African Risk and Vulnerability Atlas |

| | |
|---|---|
| SFHA | Special flood hazard area |
| SLRR | Sea level rise risk |
| TEGoVA | The European Group of Valuers' Association |
| UNFCCC | United Nations Framework Convention on Climate Change |
| USA | United States of America |

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# CHAPTER 1

# CONTEXTUALISATION

## 1.1 BACKGROUND

‘*The decision to buy residential property may be one of the most important transactions people will ever make, and the emotional attachment when houses become homes is inevitable*’ (Salzman & Zwinkels, 2013:1).

The decision to buy coastal residential property is, however, influenced by different events such as the storm swell on the South African KwaZulu-Natal coast in March 2007. This event caused physical damage and behaviour changes in the South African coastal residential real estate market. The damage caused by the storm was estimated to be more than R1 billion (Smith, Guastella, Bundy & Mather, 2007). According to Property 24, selling prices along the South African north coast declined as a result of the storm damage in 2007 (Smit, 2007).

Hughes highlighted this vulnerability of beachfront or coastal property in South Africa as early as 1992. He researched the impact of sea level rise on the South African coastal environment. In his study, he found that the southern Cape coast was particularly vulnerable to storm events similar to the storm swell on the KwaZulu-Natal coast of March 2007 (Hughes, 1992). He identified Knysna and Sedgefield in South Africa as some of the most likely places for similar storm events to occur. His findings were confirmed in studies by Umvoto Africa (2010), Prestedge Retief Dresner Wijnberg (Pty) Ltd (2009), Theron and Rossouw (2008), Cartwright, Brundrit and Fairhurst (2008) and Midgley et al. (2005).

In 2016, the Knysna Municipality released a draft strategic environmental assessment for public comment as part of their Integrated Strategic Development Framework. According to the assessment, Sedgefield, Swartvlei and the Swartvlei Estuary are exposed to a number of hazards, namely seawater surges, river flooding, ponding, overtopping, erosion and wave run-up (CSIR, 2014).

The unpredictability of storm events and the subsequent decline in selling prices of properties after such storms have created another variable for property valuers who rely predominantly on historical data and economic trends to estimate the market value of immovable property. The evidence provided in the IPCC's assessment reports predicts that the frequency and intensity of storm events such as these will increase as the world becomes warmer (IPCC, 2013). The rising sea levels will thus create additional risk, have a negative impact on real estate prices and the insurance coefficients of at-risk properties, and eventually threaten the well-being of people living along the coast. In terms of section 24 of the South African Constitution, *'everyone has the right - (a) to an environment that is not harmful to their health or and well-being; and (b) have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures'* (South Africa, 1996).

South Africa is a signatory to several international treaties and protocols on climate change. These include the United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol in 2002 and the Paris Climate Change Agreement in 2016. To accomplish their fiduciary responsibility the South African government initiated the development of the South African Risk and Vulnerability Atlas (SARVA) and the promulgation of environmental laws. The National Environmental Management: Integrated Coastal Management Act (ICM Act) 24 of 2008 was promulgated in anticipation of the potential impact of a rise in sea levels along the South African coast on coastal properties (South Africa, 2008). The Act governs, among other things, unsuitable property development and its detrimental consequences on the coastal environment (South Africa, 2008).

The emerging nature of climate change and the promulgation of the ICM Act to adapt to and mitigate the rising sea level raised the question of how property valuers will take the risk created by the changing climate and rising sea levels into account when they develop an opinion of value.

Although considerable research has been conducted on climate change and its impact on the environment, limited research has been conducted on the effect of climate change on market value of immovable property and its determination. Studies focus more on the impact of flooding and erosion on property prices (Below, Beracha & Skiba, 2015; Turnbull, Zahirovic-Herbert & Mothorpe, 2013; Bin, Kruse & Landry, 2008; Lamond, Proverbs & Hammond, 2009; Lamond, Proverbs & Antwi, 2007a and 2007b; Lamond & Proverbs, 2006).

A number of studies attempted to quantify the potential risk of climate change on immovable property in economic terms. In two of these studies (Hennecke, Greve, Cowell & Thom, 2004; Cartwright, 2008), the economic value of land was based on the average value of land in an entire suburb and no distinction was made with regard to the location of such properties, for example seafront or inland properties. This is contrary to standard valuation practice, which requires a comparison of like with like (Appraisal Institute, 2013).

Research on the effect of climate change within the property valuation community is lacking. While the effect of flooding on the value of real estate is well researched, only a few studies specifically refer to the effect of the changing climate on the market value of coastal residential property (Cradduck, 2016; Sheehan, 2012; Bienert, Wagger & Steixner, 2008; Bin & Kruse, 2006).



According to Bin and Kruse (2006), real estate development and the population within the coastal zone has grown steadily and over the past 50 years the value of coastal real estate on average has increased by 7% per annum. They also underline the long-term effect of the rising sea level on coastal real estate. Bienert et al. (2008) were among the first researchers to draw a direct link between the changing climate and its effect on the market value of immovable property: *'today's value of land is always the current value of future profit potentials. If this future profit is restricted due to climate change, it has to be considered in today's value.'* Although Bienert et al. (2008) drew the valuation community's attention to the impact of climate change on the market value of immovable property, they conducted no follow-up studies. Sheehan (2012) is of the opinion that real estate values are not affected by the rising sea level. Cradduck (2016) argues that it is not whether the future risk must be taken into account, but rather whether property valuers will correctly identify the risk and include it in their valuation reports.

## 1.2 CLIMATE CHANGE

The emerging nature of climate change has raised the question of how and to what extent the changing climate will affect the decision-making behaviour of property valuers.

According to Rudman (2007), the changing climate is a reality that may have far-reaching social, economic and environmental consequences. A result of the predicted global increase in temperature of between 1° and 4° C by 2100 will change weather and precipitation patterns as well as raise the sea level by 0.60 m or more (Nicholls, Wong, Burkett, Codignotto, Hay, McLean, Ragoonaden & Woodroffe, 2007).

### 1.2.1 Rising sea level

The predicted rise in sea level is indicated in Figure 1.1.

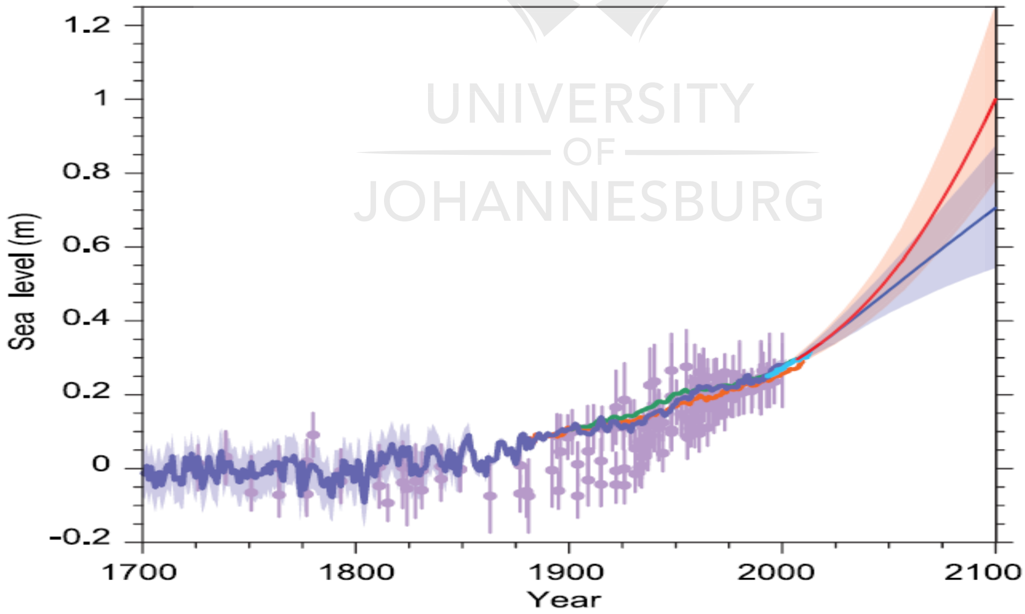


**Figure 1.1: Global mean sea level rise**

***Source:*** *IPCC (2013:1204)*

In Figure 1.1 the blue line and blue shaded area indicate the lowest predicted increase in the global mean sea level, and the red line and red shaded area indicate the highest predicted increase (IPCC, 2013). The predictions are based on the representative concentration pathway (RCP) trajectories of four greenhouse gas concentrations as accepted by the IPCC in their fifth assessment report (AR5) (IPCC, 2013).

The rise in sea level is the result of a thermal expansion of the oceans, melting of the ice caps and glaciers and an increase in the ice discharge from the ice sheets in Greenland and Antarctica (Nicholls et al., 2007).

The IPCC's predictions of sea level rise were also confirmed for South Africa by a study of the South African tide gauge records over the past 30 years (Theron & Rossouw, 2008). Theron and Rossouw's study also confirmed the findings of an earlier study conducted by Hughes (1992) in which he found that the predicted rise in sea level will be accompanied by beach erosion, flooding and inundation, saltwater intrusion and elevated coastal groundwater tables and storm damage.

Mather and Stretch (2012) contend that to mitigate the risk associated with rising sea level, decision making is hampered by inadequate information regarding the effect of the rising sea level and severe storms. Decision making is also complicated by the variable increase in sea level along the South African coastline (Mather, Garland & Stretch, 2009).



Since 2005 a number of studies have recognised the coastal area of Mossel Bay to Nature's Valley in South Africa as one of the areas most vulnerable to the effect of the rising sea level (Prestedge Retief Dresner Wijnberg (Pty) Ltd, 2009; Theron & Rossouw, 2008; Cartwright et al., 2008; Midgley et al., 2005).

### 1.2.2 Economic impact of the rising sea level in South Africa

In two South African coastal risk assessment studies, an attempt was made to establish the impact of a rise in sea level and the associated hazards on the local economy. The first was a study conducted by Cartwright in 2008 for the City of Cape Town with the primary aim: '*To model and understand the ramifications of predicted* *sea-level rise and increased storm events for the City of Cape Town, thereby providing information that may be used for future planning, preparedness and risk mitigation*'. In the study, Cartwright refers to the diverse group of people and institutions that will be influenced by a rise in the sea level and the distinctly different values they will place on the affected goods and services. The group of people he refers to includes the owners of immovable property who would like to know what it will cost to replace equipment and property lost in a sea level rise event, commercial enterprises that will be concerned with the loss of income due to the damage to infrastructure and insurance claims and public entities that will be concerned with the loss of life and of rates and taxes.

Cartwright (2008) explains that it is a common mistake in environmental risk analysis to equate replacement cost with economic loss. He indicates that opportunity cost should rather be applied when environmental damage is assessed and that opportunity cost is mostly less than financial costs. Financial costs refer to the direct cost to replace, for example, damaged infrastructure or to replace a damaged item and disregard the fact that the money to repair the damage might have been assigned to another project. Opportunity cost refers to the missed opportunity to complete the other project (Cartwright, 2008).



Cartwright (2008) quantified the economic impact of sea level rise by using the City of Cape Town's valuation roll as a basis to determine a rate per square metre for coastal land. He assumed that the rising sea level would affect beachfront and neighbouring properties. He also assumed that the average value of all affected properties would decline.

Based on these assumptions, Cartwright (2008) divided coastal real estate into three value ranges, namely low, medium and high value. He then applied the weighted average for land to three scenarios representing a 2.5 m, 4.5 m and 6.5 m rise in sea level. He calculated the estimated economic loss of private property around the Cape Town coastline at "*R3.2 billion for Scenario 1, R19.5 billion for Scenario 2 and R44.5 billion for Scenario 3*" (Cartwright, 2008). Although the basis for the baseline (City of Cape Town, valuation roll) used by Cartwright (2008) was market value, he altered the values by calculating averages and establishing weighted averages for land. The approach followed by Cartwright therefore deviates from valuation theory, according to which the final opinion of value should be expressed as a '*range of values or single dollar figure derived from the reconciliation of value indications*' (Appraisal Institute, 2013).

A further South African coastal risk assessment study was conducted in 2010. This study was commissioned by the provincial government of the Western Cape's Department of Environmental Affairs and Development Planning: Strategic Environmental Management. The aim was to assess the risk of sea level rise and flood hazards for the Eden District Municipality (Umvoto Africa, 2010b). According to Umvoto Africa (2010b), '*an extreme coastal event comparable to the KZN March 2007 storm could cause damage worth half the total annual budget of the Eden DM and five coastal local municipalities (LM's) combined*'.

No explanation was given of how they reached this assumption other than that it was based on the 2009/10 budget of the Eden District Municipality and the five coastal local municipalities of approximately R2,5 billion.

Based on this budget figure, they determined an economic vulnerability score expressed as a '*percentage value of the budget increasing in factors of ten, ranging from 0.004 % of the total budget (R 1 million – score of 1) to 40 % of the total budget (R 10 billion – score of 5)'* (Umvoto Africa, 2010b). Umvoto Africa did not define economic vulnerability other than to state that it was based on the total approximate economic cost in rand (Umvoto Africa, 2010b).

The methodologies applied in both these South African coastal risk assessment studies are not aligned with property valuation theory and methodology, which gives emphasis to comparable sales (Pietermaritzburg Corp v SA Breweries Ltd, 1911) and market value (South Africa, 2004a). Cartwright (2008) used the City of Cape Town's valuation roll as a basis to create weighted averages for land while Umvoto Africa (2010b) simply applied a percentage of the affected local authority's 2010 budget. Both these methods were used to determine the overall economic impact of the rising sea level and flood risk on disaster-prone areas along the Western Cape coast and cannot be used to determine the economic impact on a specific property.

### 1.2.3 Global assessment of the changing sea level on real estate values

In a study conducted by Heberger, Cooley, Herrera, Gleick and Moore (2009) in California, USA, the replacement value of property was used to estimate the economic impact of sea level rise. They acknowledge that there is a difference between replacement cost and market value and indicate that market values are higher due to a number of site-specific factors, whereas replacement value is based on national average construction costs.

According to the authors, their analysis was restricted by limitations related to economic valuation methodology. In their analysis of floods, they applied the replacement value of buildings and their content to estimate the economic cost of a rise in sea level. They clearly state that they did not use the property or land value, which is much higher; however, they indicate that it should be applied if the land is permanently inundated or abandoned. They further comment that replacement value could not be applied to estimate the cost of erosion as erosion is the result of the total loss of property and land. In conclusion, they point out that a rough estimation of land values along the coast was made but additional studies were needed (Heberger et al., 2009).



King et al. (2010) applied the assessed value of structures to determine the economic cost of the rising sea level in California, USA. They define the assessed value of a structure as "*a form of depreciated valuation, which captures the remaining economic life and value of a good, at the time it is damaged. This is not only a function of age, but also character and condition of assets*". The authors draw attention to the fact that data regarding age, character and condition of assets was not readily available and they therefore valued properties at risk to flooding and erosion using a constant depreciation factor of 25% (King et al., 2010:28). They indicate that although they relied on the depreciated replacement value to estimate damages to a structure, the market value of land will be better suited to estimate the damage to land due to erosion or inundation (King et al., 2010:27). King et al. (2010:31) erroneously argue that the sales comparison approach is the *'ideal method to use when there are limited market* *sales'.* The opposite is true as the sales comparison approach depends on sales data to estimate the market value of a subject property (Appraisal Institute, 2013).

In Australia a study conducted by Hennecke et al. (2004:460) concluded that because land values are available and regularly updated, they could be used for the purpose of the analysis undertaken in their study. Greve, Cowell and Thom (2000:144) define land value as the '*value of land without the value of improvement such as buildings*'. Their definition corresponds with the Appraisal Institute's definition of land value (2013:359), which states that land value is the value of vacant or raw land.

Land value is applied as the basis of valuation to determine assessment rates in Australia (Hennecke et al., 2004). Assessment rates are an easily accessible source of data for researchers. Although King et al. (2010) applied the assessed value of real estate to corroborate the economic impact of the rising sea level, they did admit that using market value would have been a more suitable approach. King et al.'s argument directs attention to the use of market value as applied in property valuation theory to determine the economic impact of the rising sea level on coastal residential real estate.

### 1.2.4 Economic loss due to the rising sea level



King et al. (2010), Umvoto Africa (2010b), Heberger et al. (2009), Cartwright (2008) and Hennecke et al. (2004) agree that the predicted rise in sea level will result in an economic loss for coastal communities. In their attempts to identify the quantum of the economic loss, a variety of methodologies were applied. The well-defined valuation methodology property valuers use to interpret and analyse the real estate market in an attempt to estimate and develop an opinion of the market value of fixed property traded in the open market was not sufficiently considered (Betts & Ely, 2005).

Cartwright, Brundrit and Fairhurst (2008) applied the market values reflected in the City of Cape Town's valuation roll as a basis to determine averages and weighted averages for land to arrive at an estimate economic loss due to a rise in sea level. In Umvoto Africa's study (2010b), a percentage value of the Eden District Municipality and five coastal local authorities' total budget was applied to determine an economic vulnerability score, which equates to a monetary figure. In California Heberger et al.

(2009) applied replacement cost as a basis to estimate the economic impact of sea level rise, whereas King et al. (2010) applied the assessed value to determine the economic cost of sea level rise. In Australia Hennecke et al. (2004) applied land value to determine the vulnerability of potential land and property loss.

None of the above studies applied market value as the basis to determine the potential economic loss to coastal infrastructure due to a changing climate. The different approaches to determine the impact of rising sea levels on real property suggest that there is uncertainty in the literature regarding a homogeneous methodology to estimate the actual economic cost of rising sea level on real property.

The South African courts and property valuers in South Africa (SA) prefer market value as a basis to value real property. Market value is defined in the International Valuation Standards (IVSC, 2013:5) as '*the estimated amount for which an asset or liability should exchange on the valuation date between a willing buyer and a willing seller in an arm's length transaction, after proper marketing and where the parties had each acted knowledgeably, prudently and without compulsion*'. The application of market value is further complicated by the promulgation of environmental legislation to adapt to or mitigate the changing climate.



### 1.2.5 Legislative impact of the rising sea level on real property

In 2008, the effect of the rising sea level in South Africa became a reality for property valuers to consider with the promulgation of the ICM Act 24 of 2008. The purpose of the Act (South Africa, 2008:2) is to:

> … *establish a system of integrated coastal and estuarine management in the Republic, including norms, standards and policies, in order to promote the conservation of the coastal environment, and maintain the natural attributes of coastal landscapes and seascapes, and to ensure that development and the use of natural resources within the coastal zone is socially and economically justifiable and ecologically sustainable; to define rights and duties in relation to coastal areas; to determine the responsibilities of organs of state in relation to coastal areas; to prohibit incineration at sea; to control dumping at sea, pollution in the coastal zone, inappropriate development of*

> *the coastal environment and other adverse effects on the coastal environment; to give effect to South Africa's international obligations in relation to coastal matters; and to provide for matters connected therewith*.

To achieve these goals the affected provincial governments have embarked on a process to delineate a coastal management line (CML) and risk zones along the South African coastline. The CML and risk zones will affect the highest and best use of coastal residential real estate and its market value in South Africa. In the future, property valuers will therefore have to consider the imminent risk of the rising sea level in their interpretation and analysis of the coastal real estate market.

### 1.2.6 Climate change risk

The risk associated with the changing climate is on the increase and there is a need to quantify this risk. Studies by King et al. (2010), Umvoto Africa (2010), Heberger et al. (2009), Cartwright (2008); Hennecke et al. (2004) applied a variety of methodologies not related to market value, or a manipulated form of market value to quantify the economic loss due to climate change risk.

Financial decisions regarding property, plant and equipment should be based on the concept of market value (IVSC, 2013). But, since property valuers base market value on past market information, the question is: '*How will property valuers change their current decision-making behaviour of considering past market behaviour to arrive at an opinion of market value to include climate change risk which is predicted for future events'*? This gap in knowledge was also identified by Bienert et al. (2008:6): *'the influence of climatic conditions on the value of land … and the effects of climate change on future real estate values'* has yet to be scientifically investigated.

To address the gap in knowledge, the following thesis statement was formulated: 'The rising sea level limits the future utility of coastal residential properties in Sedgefield, South Africa and the declining future benefits are not reflected in valuers' opinions of value'.

An instrument will be developed to assist property valuers in identifying and quantifying the climate change risk to which coastal residential properties are exposed.

## 1.3 RESEARCH PROBLEM

Climate change is a phenomenon which has an impact on the global economy (Stern, 2007). One of the consequences of climate change is rising sea levels. The question is what economic effect the rising sea level will have on the market value of coastal residential real estate.

According to the Appraisal Institute (2013:24), 'the *economic concept of value is not inherent in the commodity…*' [but] '*… is created in the minds of individuals who make up the market'*. The economic concept of value can be one of a range of values depending on a client's requirement. The IVSs refer to a number of values, namely '*fair value, investment value, market value, special value and synergistic value'* (IVSC, 2013:5-6). Additional values are *'use value, going-concern value, public interest value, assessed value and insurable value'* (Appraisal Institute, 2013:60).

Property valuers are employed to analyse and interpret a real estate market in an attempt to estimate and develop an opinion of the market value of immovable property (Betts & Ely, 2005). To develop an opinion of value property, valuers rely on information from the past to arrive at a value on the date of valuation. Ratcliff (1979:2) argues that '*only recent transactions can be used in the analysis of recent market behaviour, and the forecast is as of today or the near future*'.

The IVSs require that property valuers consider the impact of events that might affect the future value of the subject property during the extent of a loan (IVSC, 2013). The IVSs also expect that property valuers will consider the impact of any special assumptions. A special assumption is when the property valuer assumes facts that differ from the facts on the valuation date (IVSC, 2013). The changing climate is an example of a special assumption.

The emerging nature of climate change and the slow rise in the sea level is not a single event but an event with a very long duration interspersed with an ever-increasing number of activities, for example storm surges (IPCC, 2013). Measuring the impact of climate change relies on predictions of what might happen in the future, either in the short or long term. Predictions regarding the rising sea levels are based on model results, which vary considerably; see Figure 1.1 (IPCC, 2013). Property valuers in South Africa therefore cannot confidently rely on these models or the past to provide the necessary perspective for prophecy referred to by Ratcliff (1979) when they deal with a rise in sea level change risk. Bienert et al. (2008:8) argue that the rising sea level will negatively affect the future benefits of an investment in coastal residential real estate and it must therefore be considered in today's value.

The damaging effect and associated risks of the rising sea level on coastal residential real estate became prominent in SA with the promulgation of the ICM Act (South Africa, 2014a). The delineation of a CML and the identification of risk zones provide a clear indication of which coastal residential properties are at risk of eventually being flooded or inundated by the rising sea level. Properties situated in the risk zones are subject to specific development requirements, which will have a considerable impact on the development cost and on what may or may not be erected on at-risk properties. The limitations on development in the risk zones will affect the market value of all the properties within these zones even though the impact of the rising sea level is not yet visible. Property valuers will have to take the impact of the Act into account when they receive an assignment to determine the market value of coastal residential properties.

The problem is that the rising sea level and the subsequent promulgation of the ICM Act creates a risk, which will decrease the future benefits of coastal residential real estate in South Africa. To date there are no acceptable mechanisms for property valuers to quantify this risk.

## 1.4 PURPOSE STATEMENT

Since no previous studies exploring property valuers' experience concerning climate change risk was found in the literature, the researcher decided to conduct a phenomenological study to determine property valuers' lived experience of the rising sea level and to develop an instrument to assist property valuers in valuing coastal residential properties.

## 1.5 RESEARCH QUESTION AND SUBQUESTIONS

The central research question is: How does the predicted rise in sea level and its ensuing risk affect property valuers' behaviour in the coastal residential real estate market of Sedgefield in South Africa and how can property valuers quantify the climate risk?

The following subquestions were examined:

1. Are the property valuers practising in the coastal real estate market aware of climate change and the consequential risk of a rise in sea level on coastal residential real estate in Sedgefield, South Africa?
2. How do property valuers deal with the rising sea level when they develop an opinion of value in the coastal real estate market in Sedgefield, South Africa?
3. How do property valuers adapt to or mitigate the anticipated rise in sea level?
4. Are the knowledge, attitudes and behaviour of market participants a reflection of the current market behaviour in Sedgefield, South Africa?
5. How should property valuers:
   a. identify at-risk coastal residential real estate;
   b. ascertain the vulnerability level of at-risk real estate;
   c. quantify the risk; and
   d. include climate change risk when they develop an opinion of value for coastal residential real estate?

## 1.6 RESEARCH PROCESS

The focus of this study was on investigating the predicted effect and ensuing risk of a rise in sea level on the valuation behaviour of property valuers in the coastal residential real estate market and to design an instrument that can be applied by property valuers to develop an opinion of the market value of coastal residential properties in Sedgefield, South Africa.

### 1.6.1 Research philosophy

A research paradigm is a researcher's notion of how the world in which he or she works functions (Rossman & Rallis, 2003). The research paradigm of this study was directed by the pragmatic worldview of a property valuer in the coastal residential real estate market in South Africa. According to Creswell (2014), pragmatism is concerned with situations, actions and consequences as opposed to post-positivism which identifies and determines the reasons that affect results.

Property valuers are pragmatists who are real-world practice-oriented, problem-centred and attentive to the consequences of events or actions that influence a specific real estate market (Boyd, 2014; McCluskey & Borst, 2007). In order to understand a specific real estate market, property valuers rely on past sales within that market. Information regarding the past sales is acquired in a quantitative data format and analysed using quantitative data analysis techniques. Consequently, property valuers use quantitative data to interpret the behaviour of market participants when they develop an opinion of value. This is in agreement with Levy and Henry's finding (2003) that the majority of articles published in academic real estate journals use quantitative research techniques. However, Levy (2006) is of the opinion that the use of quantitative research techniques is problematic when the aim of the research is to understand or to discover influences associated with a phenomenon. She further purports that if the aim of the research is to develop an understanding of an actual phenomenon, a qualitative methodology may be the most appropriate (Levy, 2006). Levy's argument and the researcher's pragmatic worldview guided the decision to employ a mixed methods research design in this study.

### 1.6.2 Research design

According to Yin (2014), the research design is an approach which logically connects research objectives, the evidence to be collected and the analyses to answer the research question. Creswell (2014) describes three approaches that can be employed to collect and analyse evidence: a qualitative, quantitative or mixed methods approach. Each one of these approaches is underpinned by specific philosophical assumptions, applies different strategies of inquiry and uses different methods to collect data (Creswell, 2014). In this study, the researcher's philosophical worldview of pragmatism influenced the decision to pursue a mixed methods research design.

***Mixed methods research design***

The pragmatic worldview focuses on the outcomes of the research and does not rely on only one approach to collect data (Creswell, 2014). Pragmatism applies both quantitative and qualitative sources in a mixed methods approach (Creswell, 2014).

The mixed methods approach provides the researcher with an opportunity to collect, analyse and incorporate qualitative and quantitative data in one study (Creswell, 2014). Mixed methods therefore provide a broader perspective of the research and allow the researcher to use narratives, terms and pictures to expound numbers (Creswell, 2014; UKEssays, 2017). This approach permits the researcher to utilise the strengths of either the qualitative or the quantitative inquiry to overcome a limitation in the other (Creswell, 2014; UKEssays, 2017). Mixed methods provide a thorough understanding of a problem because individuals' and marginalised groups' points of view can be incorporated in the research (Creswell, 2014). However, the researcher must pay attention to the inherent challenges in the mixed methods approach. These include the collection of different sets of data and their analysis. The multifaceted nature of a mixed methods approach requires that the researcher have a well-defined concept of how the research will progress (Creswell, 2014).

In this study a mixed methods approach was pursued by means of a two-stage sequential exploratory design, beginning with an initial phase of qualitative data collection and analysis, followed by a phase of quantitative data collection and analysis.

Exploratory research is defined as "*a methodological approach that is primarily concerned with discovery and with generating or building theory*" (Jupp, 2006:110).

### 1.6.3 Research approach

The purpose of this exploratory sequential design was to develop an in-depth understanding of the climate change phenomenon and specifically the effect of the rising sea level and the introduction of the ICM in order to design an instrument that can be applied by property valuers when they develop an opinion of market value for coastal residential property. The sequential exploratory design comprised two stages. In the first stage a phenomenological research strategy was pursued to gain insight into property valuers' knowledge, attitudes and behaviour regarding the changing climate and the risks associated with it. In the second stage, a case study research strategy was followed to establish if the knowledge, attitudes and behaviour of property valuers are a reflection of the current real estate market in Sedgefield.

#### *1.6.3.1 Stage 1: Phenomenological research and qualitative inquiry*

The aim of phenomenological research is to describe the lived experience of the participants in a study (Maypole & Davies, 2001; Robinson & Reed, 1998; Greene, 1997). Phenomenology therefore investigates an event such as the changing climate from an individual's point of view (Lester, 1999). Levy (2006:369) argues that '*real estate academics'* should not restrict their research to quantitative studies only but should investigate the behavioural aspects of real estate markets by conducting qualitative studies.

The aim of the first stage of this study was to investigate the lived experience of property valuers regarding the climate change phenomenon on property valuation practices in South Africa over a period. Through qualitative inquiry, the study focused on the knowledge, attitudes and behaviour of property valuers regarding the risk inherent in the rising sea level and the effect of the ICM Act.

#### *1.6.3.2 Stage 2: Case study research and quantitative inquiry*

Case study research '*investigates a contemporary phenomenon in depth and in its real-world context*' (Yin, 2014). The aim of the case study research in stage 2 was to establish if the knowledge, attitudes and behaviour of property valuers regarding the rising sea level and the ICM Act are a reflection of the current market behaviour in Sedgefield. According to Ratcliff (1979), property valuers interpret human behaviour when they develop an opinion of value. Property valuers' opinion of value in the Sedgefield real estate market should therefore be a reflection of how market participants (buyers and sellers) behave in the Sedgefield real estate market.

Two areas within Sedgefield were chosen, and sales data was collected for both areas over the past 20 years and statistically compared to ensure that the two areas were comparable.

### 1.6.4 Data collection and analysis

Two different sets of data were collected. The first was primary data collected through interviews and the second secondary data, i.e. sales data from the two selected sites in Sedgefield.

#### *1.6.4.1 Sampling strategy*

A research population represents the total collection of individuals or entities in a study from which a researcher wants to draw conclusions (Welman, Kruger & Mitchell, 2009). Ritchie and Lewis (2003:86) refer to a parent population and define it as '*the population from which the sample is to be drawn'*. They suggest that the researcher select subjects who can provide rich information central to the research question, exclude subjects who cannot contribute information and consider other subjects who may contribute to the outcome of the study (Ritchie & Lewis, 2003). The population for this study can be described as all registered property valuers who may engage in the valuation of coastal residential properties along the South African coastline.

Qualitative researchers apply purposeful sampling to identify participants or locations to study (Creswell, 2014). Purposeful sampling allows the researcher to select participants and locations that have experienced the phenomenon being studied (Creswell, 2014).

In a phenomenological study the selection of participants is called criterion sampling because the purpose of the study is not to generalise but to explain the unusual (Creswell, 2014). Ritchie and Lewis (2003) refer to this as non-probability sampling. According to Ritchie and Lewis (2003:78), purposive sampling is applied in qualitative research because the intention is to select participants who exhibit particular features of the population and the sample is not intended to be statistically representative.

From the population a non-probability or criterion sample was drawn, namely all professional associated valuers and professional property valuers who resided on the southern Cape coast (Mossel Bay to Nature's Valley). Property valuers on the southern Cape coast were purposefully chosen since this area was identified by Hughes (1992) as one of four particular areas along the South African coast vulnerable to the rising sea level. The particular areas are Greater Cape Town (Melkbosstrand to Gordon's Bay), southern Cape coast (Mossel Bay to Nature's Valley), Port Elizabeth, and KwaZulu-Natal south coast and Greater Durban (Southbroom to Ballitoville). The southern Cape coast and specifically Knysna and Sedgefield were singled out, as the area is most vulnerable to the rising sea level (Hughes, 1992).

Due to its vulnerability to the rising sea level (Umvoto Africa, 2010; Hughes, 1992) and the number of floods experienced in 2003, 2006, 2007 and 2015 (Kirsten, 2015), Sedgefield was chosen as the research site. Property valuers conducting valuations in this area should therefore be the first to encounter the effect of the rising sea level on coastal residential properties.

#### *1.6.4.2 Stage 1*

**a) Data collection**

Structured interviews with closed and open-ended questions were used as the research instrument to collect data. The open-ended questions in the structured interview allowed themes to emerge from the interview narratives (Miles & Huberman, 1994). The purpose of the open-ended questions in the structured interview was to allow the researcher to interrogate the property valuers' knowledge, behaviour and attitudes regarding the changing climate, specifically the rising sea level, when they develop opinions of value. The structured interview assisted the researcher in remaining neutral and allowed for a direct comparison of the responses. It also eliminated inconsistency in questions, thus ensuring reliability and validity (Cooper & Schindler, 2008).

A non-probability purposive sample was drawn by inviting all registered professional valuers and professional associated property valuers who regularly conducted valuations along the southern Cape coast and Sedgefield to participate. The membership list of the South African Council for the Property Valuers Profession was used to identify registered professional valuers and professional associated property valuers in the municipalities of Knysna, George, Mossel Bay and Eden District Municipality, as they were the most likely to conduct valuations on the southern Cape coast and in Sedgefield.

**b) Data analysis**

According to Henning, Van Rensburg and Smit (2004), the analysis of qualitative research data is a continuing, developing, repetitive and non-linear process. The data was analysed according to the coding process for qualitative data as described by Saldaña (2012). In the first cycle, holistic coding was applied to identify broad topic areas. In the second cycle, the broad topics were subdivided into 28 descriptive codes and pattern coding was applied in the third cycle to categorise the codes and theme the data (Saldaña, 2012).

The intention was to use Atlas.ti to analyse the data. According to Basit (2003), a researcher's decision to analyse qualitative data manually or electronically is influenced by the size of the project. In this study 13 interviews were conducted owing to funding and time constraints and the fact that 11 of the interviews were conducted in Afrikaans, and not English. The majority of the participants elected to conduct the interviews in their home language, Afrikaans.

#### *1.6.4.3 Stage 2*

**a) Data collection**

Secondary data was collected for Sedgefield, one of the areas on the southern Cape coast most vulnerable to the rising sea level. Sales data for the last 20 years was sourced for two suburbs in Sedgefield from the South African Property Transfer Guide (SAPTG). The SAPTG is a database that provides easy access to data from the deeds office. The secondary data provided by the SAPTG is reliable and valid as it is obtained directly from the different deeds offices in South Africa. All property transactions are recorded in the deeds offices in accordance with the Deeds Registries Act 47 of 1937 (South Africa, 1937).

A non-probability procedure was followed to draw a sample of properties from two suburbs, Sedgefield Island and Sedgehill, in Sedgefield. Sedgefield Island is generally lower than 5 m above mean sea level (amsl), and thus vulnerable to a rise in sea level; Sedgehill is higher than 20 amsl, and thus not vulnerable to the rising sea level (Google Earth, 2015).

A non-probability sample is arbitrary and subjective, according to Cooper and Schindler (2008). The sample of the study was, however, deliberately selected as only properties that sold more than once in the last 20 years were necessary to establish trends in selling prices and to determine if there was any relationship between selling prices, flood events and rising sea levels or events that can be linked to climate change.

**b) Data analysis**

Non-parametric statistical tests were conducted on the data sets for Sedgefield Island and Sedgehill, to establish if past floods, height above sea level and distance to the water had any influence on the behaviour of purchasers and sellers in the specific real estate markets.

Descriptive statistics confirmed that the two selected areas in Sedgefield were comparable.

## 1.7 ASSUMPTIONS, DELIMITATIONS AND LIMITATIONS

This study was conducted from a property valuer's point of view and was restricted to coastal residential property on the southern Cape coast with specific interest in Sedgefield. The study was further limited to property valuers' knowledge, behaviour and attitudes when they develop an opinion of value for coastal residential properties at risk of being affected by the rising sea level. This research explored property valuers' knowledge, behaviour and attitude regarding the changing climate with specific reference to the rising sea level and its accompanying complications on the southern Cape coast and specifically Sedgefield.

The following aspects of property valuers' decision-making behaviour were not purposefully investigated, namely anchoring and adjustment bias, client influence, lack of market information and market feedback. The aim of the study was not to generalise but to glean an understanding of property valuers' knowledge, attitudes and behaviour regarding the effect of the changing climate on their practices in a specific location, namely Sedgefield, in order to develop an instrument property valuers can use to quantify the risk created by the rising sea level.

## 1.8 ETHICS



To comply with ethical requirements:

- no potentially sensitive questions were asked;
- the purpose of the interview was clearly stated before commencing the interview;
- participants were informed that their participation was voluntary and that they could accept or refuse to participate;
- confidentiality and anonymity were assured;
- the results of the study were reported accurately without any bias from the researcher or any participant;
- the secondary data obtained was analysed by means of valid statistical techniques.

## 1.9 CONTRIBUTION OF THE STUDY

This study explores the knowledge, attitudes and behaviour of property valuers in Sedgefield, South Africa who are confronted with the influence of the rising sea level on the market value of coastal residential real estate. A model is developed that property valuers can use to quantify the risk to which coastal residential properties are exposed. The instrument provides guidelines to property valuers to identify at-risk properties, a risk matrix to define the different levels of risk, and suggests an approach to quantify the potential risk.

This instrument is of special importance to residential property valuers who rely on sales transactions to develop an opinion of value.

## 1.10 STRUCTURE OF THE THESIS

This thesis is presented in eight chapters. Chapter 1 introduces the study, while chapter 2 reports on the literature underlying the climate change phenomenon, the literature behind the valuation process in South Africa is reviewed in chapter 3, chapter 4 presents the research design and methodology followed in the study and chapters 5 and 6 present the results and findings of phases 1 and 2. In chapter 7 climate change risk and the applicability or not of different models applied by property valuers when they consider the impact of the rising sea level on the market value of coastal residential property are discussed. An instrument to assist property valuers in South Africa in quantifying climate change risk is presented in Chapter 7. Chapter 8 concludes the study with a discussion of the findings, and some recommendations for further studies. Figure 1.2 provides a framework of the research.

| | | |
|---|---|---|
| **Introduction** | *Contextualisation of the research* | Chapter 1 |
| **Literature review** | *The changing climate* | Chapter 2 |
| | *The property valuers' paradigm and sea level rise risk* | Chapter 3 |
| **Research design** | *Sequential exploratory mixed methods design* | Chapter 4 |
| **Empirical research** | | |
| **Qualitative data** | *Review of property valuers' knowledge, behaviour and attitudes on the changing climate* | Chapter 5 |
| **Quantitative data** | *Quantitative data analysis and results* | Chapter 6 |
| **Instrument design** | *Quantifying sea level rise risk* | Chapter 7 |
| **Conclusion** | *Overview, conclusion and recommendations* | Chapter 8 |

**Figure 1.2: Framework of the study**

## 1.11 SUMMARY

This study sought to explore the knowledge, behaviour and attitudes of property valuers regarding the risk created by the emerging nature of climate change and the National Environmental Management: Integrated Coastal Management Act on their current practices.

A phenomenological study was conducted to determine property valuers' lived experience of the rising sea level in order to develop an instrument to assist them when they value coastal residential properties. To achieve this, a central research question was formulated: How does the predicted rise in sea level and its ensuing risk affect property valuers' behaviour in the coastal residential real estate market in South Africa and how should property valuers quantify the climate risk? The central question was divided into several subquestions. The first subquestion aimed to establish if property valuers practising in the coastal real estate market are aware of climate change and the consequential risk of a rise in sea level on coastal residential real estate in South Africa.

The second subquestion aimed to confirm how property valuers deal with the rising sea level when they explore the coastal real estate market in South Africa. The third subquestion aimed to verify how property valuers adapt to or mitigate the anticipated rise in sea level and the fourth aimed to confirm if the knowledge, attitudes and behaviour of market participants are reflected in coastal residential real estate market in the study area. The fith and last subquestion deal with the proposed model.

The relevance of the research was confirmed with the presentation of a peer-reviewed paper, *The influence of climate change on the market value of coastal residential property in South Africa* at the International Conference on Coastal Cities and their Sustainable Future in 2015 (Annexure B).

The application of the mixed methods design utilised in the thesis and reported in a conference paper, *Exploring property valuers' knowledge, behaviour and attitude regarding climate change by means of a mixed methods research approach*, provide evidence to support Levy's argument (2006) that real estate research should not simply provide empirical descriptions. The paper was presented at the Pacific Rim Real Estate Society Conference 2018, in Auckland, New Zealand (Annexure C).

The model, developed in Chapter 7, was introduced to the international property valuation community at the Pacific Rim Real Estate Society Conference 2018. The title of the peer-reviewed paper is *Climate change risk coefficient for coastal residential real estate'* (Annexure D). The paper attempted to jump-start a debate on the subject of sea level rise risk among property valuers.

# CHAPTER 2

# THE CHANGING CLIMATE

## 2.1 INTRODUCTION

In the previous chapter, the background to the research problem was presented. The goal and objectives emanating from the research problem were given and the research design and methodology described. In this chapter, the findings of climate scientists regarding the changing climate globally and locally are reported. In the first section, climate change will be defined and a broad overview of the global climate change debate as well as the dissenting views and the changing sea levels will be provided. In the next section, the local climate change and the rising sea level will be discussed. This chapter will conclude with a discussion regarding the risk inherent in the changing climate for South Africa.

Global warming and climate change are becoming a reality that is receiving attention from different research disciplines all over the world. The threat of changing climate was discussed at COP21 in Paris from 30 November 2015 to 11 December 2015 (US Environmental Protection Agency (EPA), 2015). At the same time NASA published data indicating that October 2015 was the warmest October on record globally (Columbia, 2015).

Global warming, climate change and anthropogenic global warming are terminology ordinarily used in the debate regarding the changing climate (Small, 2009). The term "climate change" is applied when occurrences of changing climate are referred to. Although climate change can be attributed to a number of factors, there are two main schools of thought. According to Houghton (2005), the first and largest group attributes climate change to human activities, i.e. the burning of fossil fuels such as coal, oil and gas as well as extensive deforestation. This is confirmed by Stern (2007:3): '*An overwhelming body of scientific evidence indicates that the Earth's climate is rapidly changing, predominantly as a result of increases in greenhouse gases caused by human activities*.' The second group attributes climate change to, among other things, the natural variability in the weather, geologic time, fudged data, inadequate modelling, or just no evidence at all (Morano, 2010).

The changing climate is evident in an observed increase in global average surface temperature and in water temperature which result in a rise in global average sea level (Smith, Reynolds, Peterson & Lawrimore, 2008; Brohan, Kennedy, Harris, Tett & Jones, 2006; Rayner, Brohan, Parker, Folland, Kennedy, Vanicek, Ansell & Tett, 2006; Hansen, Ruedy, Sato, Imhoff, Lawrence, Easterling, Peterson & Karl, 2001).

In the northern hemisphere thinner sea ice, melting glaciers, shorter freezing seasons, a decrease in the extent of permafrost, increasing soil temperatures and a rising sea level provide additional evidence that the world is warming (IPCC, 2013). Several hazards were reported in the 5$^{th}$ IPCC report. These included the rising sea level, coastal flooding and storm surges (Campos, Warren, Birkmann, Luber, O'Neill & Takahashi, 2014). According to the US EPA (2016b), the rising sea level, coastal flooding, shoreline erosion, the intensity and frequency of storm surges and increasing rainfall will affect coastal infrastructure.

## 2.2 DEFINING CLIMATE CHANGE

Scientific institutions involved in climate change research typically distinguish between global warming, the cause of global warming, climate change and its consequences (Houghton, 2005; US Climate Change Science Program, 2007; NOAA National Climatic Data Centre, 2007; NASA, 2008; US EPA, 2016b; South Africa, Department of Science and Technology, 2008; South Africa, Department of Environmental Affairs, 2015).

Each institution defines the changing climate in its own words. The most commonly used definition is that of the UNFCCC (1992:7), which defines climate change as "*a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods*".

The IPCC (2012:557), an intergovernmental scientific body tasked with providing reports for the UNFCCC, defines climate change as '*a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use.*'

The definitions differ in that the UNFCCC distinguishes between changes to the climate due to human activity and natural causes, whereas the IPCC is more cautious when it states that climate change may be due to natural causes or anthropogenic changes in the atmosphere or land use.

The IPCC was established by the UNFCCC to determine a clear scientific view of climate change and its impending environmental and socio-economic effects (IPCC, 2014). For the purpose of this study the IPCC's definition of climate change will be applied: Climate change '*refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer*' (IPCC, 2012:557).



Having defined climate change, the background to climate change and the ensuing debate regarding climate change will be considered.

## 2.3 GLOBAL CLIMATE CHANGE DEBATE

The debate regarding climate change started in all earnest in 1988 after the first World Climate Conference and the creation of the IPCC (UNFCCC, 2012). The IPCC was established by the World Meteorological Organisation and the United Nations Environmental Programme in order to assess the scientific information associated with the changing climate and to evaluate the socio-economic concerns of climate change (Houghton, Jenkins & Ephraums, 1990).

*Climate Change the IPCC Scientific Assessment,* a report prepared for the IPCC by Working Group 1, was published in 1990 (Houghton et al., 1990). In the report a greenhouse effect created by high concentrations of atmospheric gas (CFCs, nitrous oxide and carbon oxide) emissions by human activity was identified as the main contributor to the increase in global warming (Houghton et al., 1990).

The Royal Society entered into the debate in 1989, with the publication of *The Royal Society and climate change* (Montford, 2012).

In 2005 scientific institutions from several countries issued a joint science academies' statement on a global response to climate change in which the signatories confirmed that global warming is occurring (The Royal Society, 2009).

However, the IPCC is the main disseminator of climate change information and has, since the publication of its first report, published a number of assessment reports. The first of the IPCC's assessment reports was published in 1990, the second in 1995, the third in 2001, the fourth in 2007 and the fifth and latest in 2013/2014. In these reports, the IPCC provides evidence confirming that the earth's climate is changing based on the observation of a global increase in average air and ocean temperatures as well as changing sea levels due to the extensive melting of snow and ice (IPCC, 2014).

The creation of the IPCC and the subsequent Conferences of the Parties have drawn the world's attention to the impact of the changing climate on rising sea levels and the world's economy.

## 2.4 VIEWS DISSENTING FROM THE MAINSTREAM VIEW OF CLIMATE CHANGE

Although the majority of scientists support the findings in the IPCC's reports, i.e. that the climate is changing due to global warming created by high concentrations of atmospheric gas emissions from human activity, a number of scientists disagree with these findings.

According to Carlin (2007), the attempts to reduce emissions of greenhouse gases (GHGs) under the Kyoto Protocol cannot realistically be achieved to avoid dangerous climatic changes. He proposes a system of adding particles to the stratosphere to reflect some of the incoming sunlight back into space and to commence a study to understand and reduce ocean acidification (Carlin, 2007).

Another sceptic, Kininmonth (2004; 2008) believes that the current understanding of climate mechanics is too basic to be able to identify atmospheric carbon dioxide as a prominent stimulus, and concludes that water vapour has a much more important influence on global temperature than carbon dioxide.

Khandekar, Murty and Chittibabu (2005) argue that the forecasts of future climate change are based on climate models that are not sufficiently substantiated and consequently cannot be considered reliable. They further maintain that there seems to be no link between global warming and worldwide extreme weather events and conclude that any economic impact due to extreme weather events is as a result of societal change in wealth and population, especially in the USA, and not due to global warming. According to Khandekar et al. (2005), there was no evidence of accelerated sea level rise during the 20th century.



Although Lomborg (2007), an economist, agrees that global warming is real and human-made, he argues that it is readily exaggerated. He also believes that climate change is not the only issue of global importance and is essentially an issue about which the least good can be done at present. He further argues that a reduction in GHG emissions as proposed by the Kyoto Protocol would result in large economic losses due to the cost of implementing the protocol.

Michaels and Balling (2005) acknowledge that GHGs are warming the planet and will continue to do so for a number of decades to come. However, they argue that in the future global warming will be moderate, not catastrophic and will have very little economic and ecological effect due to the insignificant consideration of land-use changes in the General Circulation Models used by the IPCC.

Another sceptic, Scafetta (2010) believes that 60% of the earth warming since 1970 is due to natural cycles in the solar system. He argues that the current General Circulation Models exclude all unknown mechanisms and mistakenly use a few such as anthropogenic GHGs to create a warming trend during a confined interval.

Although the sceptical scientists acknowledge that climate change exists, they differ from the main view regarding the cause of climate change. They attribute the cause of climate change to natural inconsistency in the weather, geologic time, fudged data, inadequate modelling, or just no evidence at all (Morano, 2010). Although their views are admitted, they are in the minority and there is no doubt that the IPCC represents the mainstream view regarding the changing climate (Garnaut, 2011).

## 2.5 CHANGING SEA LEVEL

This study focused on the influence of the changing sea level on coastal residential property. The changing sea level and the events that coincide with it, i.e. coastal flooding and extreme events, which are probably the most visible effect of climate change, will therefore be discussed.

The first IPCC assessment report based on research conducted by Ambach and Kuhn (1989), Barnett (1983), Braithwaite and Oleson (1989), Gornitz, Lebedeff and Hansen (1982), Haeberii, Bosch, Scherler, Østrem and Wallen (1988), Hoffert and Flannery (1985), Meier (1984), Oerlemans (1989), Roemmich (1985), Thomson and Tabata (1987) and Wigley and Raper (1987) and others created the foundation for the current insight into sea level change. Dynamics such as the rate of increase between the 19$^{th}$ and 20$^{th}$ centuries, thermal expansion and the contribution from glaciers were acknowledged (IPCC, 1990). Pfeffer, Harper and O'Neel (2008) later confirmed this when they suggested that the dynamic discharge from Greenland's glaciers together with thermal expansion will increase the sea level by 0.8 to 2.0 m.

According to IPCC's second assessment report, there were no new findings regarding the changing sea level (IPCC, 1995). However, in the third assessment report energy balance climate models were replaced by atmosphere-ocean general circulation models and ice-sheet models (IPCC, 2001). Huber and Gulledge (2011) indicate that a growing body of researchers to investigate the future risk regarding the changing climate uses these new climate models. Grounded in research conducted by Cazenave, Remy, Dominh and Douville (2000), Chambers, Mehlhaff, Urban, Fujii and Nerem (2002), Chen and Stanley (1998), Church, Gregory, Huybrechts, Lambeck, Nhuan, Qin and Woodworth (2001), Douglas (2001), Gornitz, Rosenzweig and Hillel (1997), Levitus, Antonov, Boyer and Stephens (2000), Milly and Shmakin (2002), Milly, Wetherald, Dune and Delworth (2002), Peltier (2001) and Sahagian and Zerbini (2000) among others, the IPCC was able to project regional differences in sea level change and not only make global projections (IPCC, 2001).

Observations of the variation in changing sea levels by means of satellite altimeter records were applied in the fourth assessment report. Relying on research conducted by Christie, Lowry, White, Oracion, Sievanen, Pomeroy, Pollnac, Patlis and Eisma (2005), Few, Brown and Tompkins (2004), Hanson, Brampton, Capobianco, Dette, Hamm, Laustrup, Lechuga and Spanhoff (2002), Harvey (2006), Isobe (2001), Kennish (2002), Moser (2005), Neumann, Yohe, Nicholls and Manion (2000), Nicholls and Klein (2006) and Williams, Coles and Primavera (2007) as well as other scientists. The IPCC indicated that the observed rise in sea level was more than the rise indicated by the models used previously. It also allowed the IPCC to have more confidence in their projections and to grasp that they did not understand the potential contribution to sea level rise from the ice sheets (IPCC, 2007).



According to Rahmstorf (2007), there is a semi-empirical relationship between global mean surface temperature and global sea level rise and he predicted a rise in sea level in 2100 of between 0.5 and 1.4 m above the 1990 mean sea level.

In the IPCC's fifth assessment report the confidence in the projections regarding the rise in the global mean sea level increased, see Figure 2.1 below. This is attributed to an improved understanding of the features of sea level, agreement on the models being used and the inclusion of dynamic ice sheet changes (IPCC, 2013; Church, Gregory, White, Platten & Mitrovica, 2011; Gregory & Lowe, 2000; Landerer, Jungclaus & Marotzke, 2007).

According to the fifth assessment report, the IPCC (2013) is highly confident that the mean sea level has been 5 m above the current mean sea level in the past, based on Paleo sea level records. Based on instrumental sea level data, it is likely that the sea level will continue to rise well into the 21st century. The rise in sea level will exceed the average rate of 3,2 mm per annum recorded between 1993 and 2010 (IPCC, 2013; Lorbacher, Marsland, Church, Griffies & Stammer, 2012; Rahmstorf, 2007).

Sea level change is affected by an increase in water temperature as well as the melting of glaciers. The IPCC is highly confident that 75% of the observed rise can be attributed to thermal expansion and glacier melting (IPCC, 2013; Miller & Douglas, 2007; Milne, Gehrels, Hughes & Tamisiea, 2009). It is very likely (90% or more) that the rate at which the sea level will continue to rise will be higher than the rate observed during 1971 – 2010. It is *very likely* that 95% of regional sea level change will be higher and 70% of the increase along global coastlines will be within 20% of the global mean sea level rise (IPCC, 2013).

In keeping with their projections, the IPCC (2013) states that it is very likely that sea level extremes and surface waves will increase significantly. A result of the rise in sea level is a considerable increase in the repeated occurrences of sea level extremes with a very likely confidence that it will carry on into the 21st century. Hunter (2010; 2012) draws attention to the fact that the projected increase in sea level and uncertainty regarding the projections should be taken into account in all coastal planning risk management frameworks. The uncertainty of the projections is exacerbated by the potential hazard of the ice shelves collapsing, which could lead to a potential rise in sea level of a number of metres (Rott, Muller, Nagler & Floricioiu, 2011).

The IPCC's findings above are supported by numerous peer-reviewed studies published regarding the anticipated effect of rising sea levels (Boretti, 2012a & 2012b; Boretti & Watson, 2012; Douglas, 2001; Douglas & Peltier, 2002; Holgate, 2007; Houston & Dean, 2011; Mörner, 2010; Scafetta, 2013 & 2014; Schmith, Johansen & Thejll, 2012; Watson, 2011; Wenzel & Schröter, 2010; Woodworth, White, Jevrejeva, Holgate, Church & Gehrels, 2009; Wunsch, Ponte & Heimbach, 2007). According to Cazenave and Nerem (2004), the changing sea level is an indication of the changing climate and ensuing socio-economic consequences for the people living close to the current mean sea level. It is therefore important to keep this potential risk in mind.

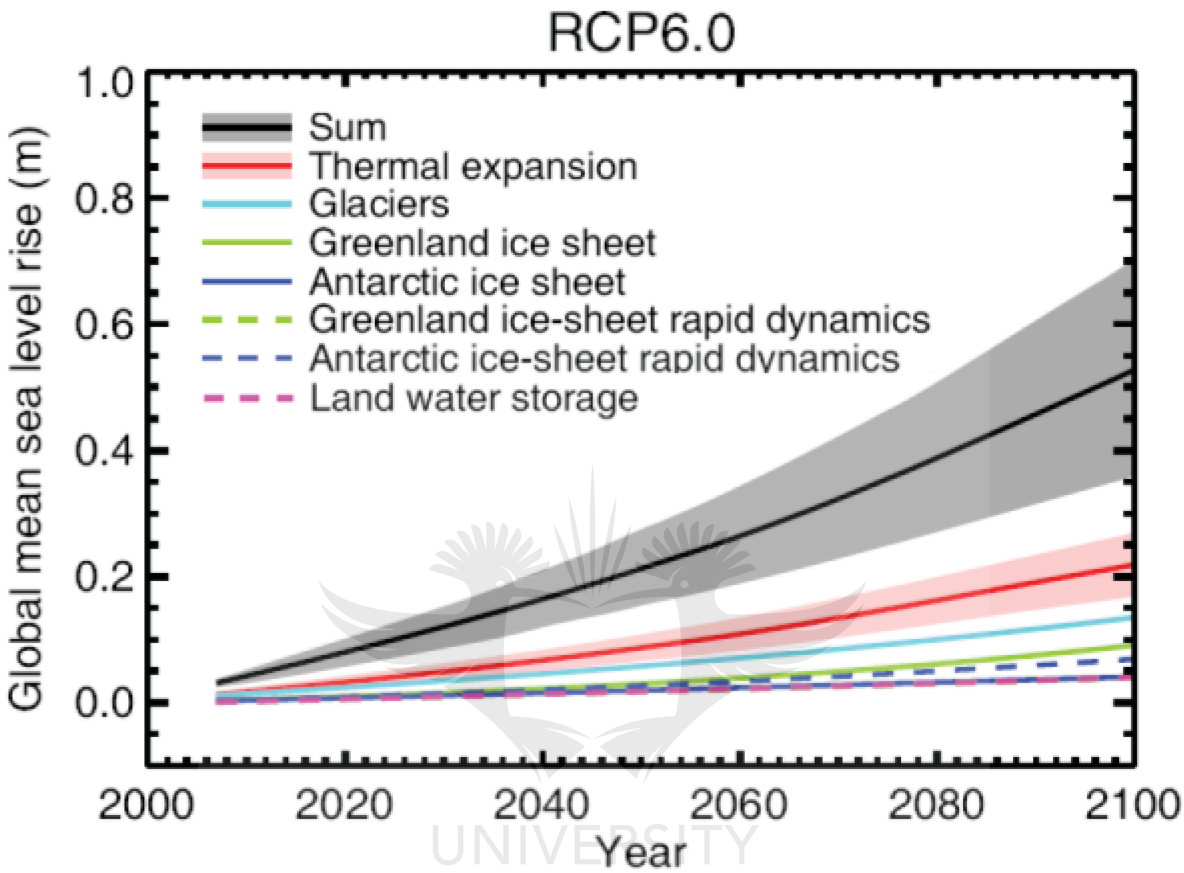


**Figure 2.1: Global mean sea level rise 2000 to 2100**
***Source:*** *IPCC (2013)*

Figure 2.1 portrays the forecast of the global mean sea level rise between 2000 and 2100. The forecast is based on scenarios generated by means of RCPs (Bjørnæs, 2015). The blue line and blue shaded area represent RCP 2.6 – low emissions; this RCP was developed by PBL Netherlands Environmental Assessment Agency and will require a zealous reduction in GHG emissions (Bjørnæs, 2015). The red line and red shaded area represent RCP 8.5 – high emissions; this scenario was developed by the International Institute for Applied System Analysis in Austria and assumes that GHG emissions will increase over time (Van Vuuren, Edmonds, Kaiuma, Riahi, Thomson, Hibbard, Hurtt, Kram, Krey, Lamarque, Masui, Meinshausen, Nakicenovic, Smith & Rose, 2011).

The IPCC's fifth assessment report predicts that sea level rise could increase flooding, particularly on the coasts of eastern Africa; this will probably increase the high socio-economic and physical exposure of coastal cities (IPCC, 2014). The increased flooding will damage property and infrastructure and will also affect coastal businesses, cause loss of wetlands, require the erection of coastal protection structures and force authorities to incur additional maintenance costs (Wei & Chatterjee, 2013). According to the IPCC (2007), the cost of adaptation to sea level rise could amount to at least 5-10% of the gross domestic product of a country.

According to the IPCC's fifth assessment report, the projected rise in sea level is very likely to exceed the observed rate of increase over the last 30 years, confirming the findings in AR4 due to the melting of glaciers and ice caps and the increased discharge from the Antarctic ice sheet and Greenland. This will increase the risks for Africa's coastal settlements considerably (IPCC, 2014). Theron and Rossouw (2008) point out that 30% of South Africa's population reside close to the coast.

## 2.6 CLIMATE CHANGE IN SOUTH AFRICA

The problems posed by a changing climate in South Africa have been scrutinised by scientists for a long time, for example by Kokot (1948), who investigated the evidence of climatic changes over Southern Africa and Tyson (1987), who studied climatic change and variability in Southern Africa in 1987. However, since 1990 the different aspects of climate change have received substantial attention by the South African scientific community. Scientists such as Wigley (2011), Blake (2010), Brundrit (1995, 2008 & 2009); Breetzke, Parak, Celliers, Mather and Colenbrander (2008), Cartwright (2008), Mather (2008), Theron and Rossouw (2008), Smith et al. (2007), Alexander (1990, 1995, 2002 & 2006), Kruger and Shongwe (2004), Turpie (1996, 2002 & 2004), Turpie and Joubert (2001), Lamberth and Turpie (2001), Wand (2001), Du Toit, Prinsloo, Durand and Kiker (2000), Fairbanks and Scholes (1999), Hughes (1992) and Schumann and Brink (1990) all conducted research on some facet of climate change in South Africa.

Several of the studies researched the effect of climate change on agriculture. For example, Du Toit et al. (2000) examined the vulnerability of maize production to climate change, while Fairbanks and Scholes (1999) investigated the effect of climate change on the forestry industry and Wand (2001) explored the impact of climate change on agriculture with specific reference to the brewing industry. Kruger and Shongwe (2004) studied the temperature trends in South Africa between 1960 and 2003 and found that the average mean trend pointed to an annual increase of 0.13 °C, which could not be attributed to El Niño or La Niña events. Their results inadvertently confirm the IPCC's finding that the global mean surface temperature is rising.

In an analysis of the potential impact of climate change on the coastal zone in the southern African region by Theron and Rossouw (2008), an increase in sea level, wind velocity, storms, altered freshwater flows and shoreline erosion were identified as some of the potential consequences of climate change. The adverse effect of some of these phenomena on the South African coastline has been well documented by Breetzke et al. (2008), Cartwright (2008), Hughes and Brundit (1991) and Smith et al. (2007).

Wigley (2011) identifies the two most important geohazards in coastal areas as the inundation of coastal land due to the rising sea level and flooding by storm surges, as well as the erosion of coastal dunes by wave action. Midgley et al. (2005) refer to the increase in extreme events, raised groundwater tables as a result of saltwater inundation, tidal influences and wave action, flooding and coastal erosion.

According to Goschen (2011), the main cause of the rising sea level is the thermal expansion of the sea water due to global warming. The warmer water provides more energy to storms, thus increasing the frequency and strength of storms.

Cartwright (2008) and Brundrit (2009) found that there is a very real possibility that the rising sea level will increase the likelihood that high seas and storm events will batter Cape Town more often than in the past. According to Cartwright (2008), the frequency of such events will also prohibit the repair of natural and engineered defences between such events. Breetzke et al. (2008:2) state that the impact of coastal erosion will become visible in the *"loss of land and damages to the built environment, destruction of natural sea defences such as dunes and undermining and failure of artificial sea defences"*. This destruction is evident in the report by Smith et al. (2007) in an investigation into the storm swell, which hit the KwaZulu-Natal coast in March 2007.

Although the storm swell was a 1:35-year event, it is predicted that as a result of the rising sea level, a similar situation will occur during every spring tide by 2100 (Theron & Rossouw, 2008). The rising sea level and the rising frequency and intensity of storms together with rising wave heights result in an increase in such events (Goschen, 2011). Smith et al. (2007) also found that the damage to coastal property in the 2007 storm swell was the result of ill-considered town planning during the coastal building boom and they estimated the damage to be more than R1 billion.

In an attempt to determine the economic impact of the rising sea level, Turpie, Winkler, Spalding-Fecher & Midgley (2002) conducted a desktop study to uncover the economic impacts of climate change on South Africa. In the study they dealt with, among other things, the rising sea level and confirmed that it is rising at a rate similar to the predicted global increase of 3,2 mm per annum (IPCC, 2013; Lorbacher et al., 2012; Rahmstorf, 2007). They also found that the southern Cape coast is more susceptible to the rising sea level than the KwaZulu-Natal coast (Turpie et al., 2002). Although they set out to determine the economic impact, they did not quantify the economic impact of the rising sea level except to comment that the rising sea level and accompanying increase in storm surges will have an impact on infrastructure (Turpie et al., 2002).

All the researchers referred to above agree that the rising sea level will have a negative impact on coastal infrastructure. However, it is the findings of Breetzke et al. (2008) regarding the loss of land and damages to infrastructure that point towards the economic loss owners of coastal residential property may have to suffer in the near future. According to Mather and Stretch (2012), the rising sea level will have a serious impact on beachfronts, as indicated in Figure 2.2 below.

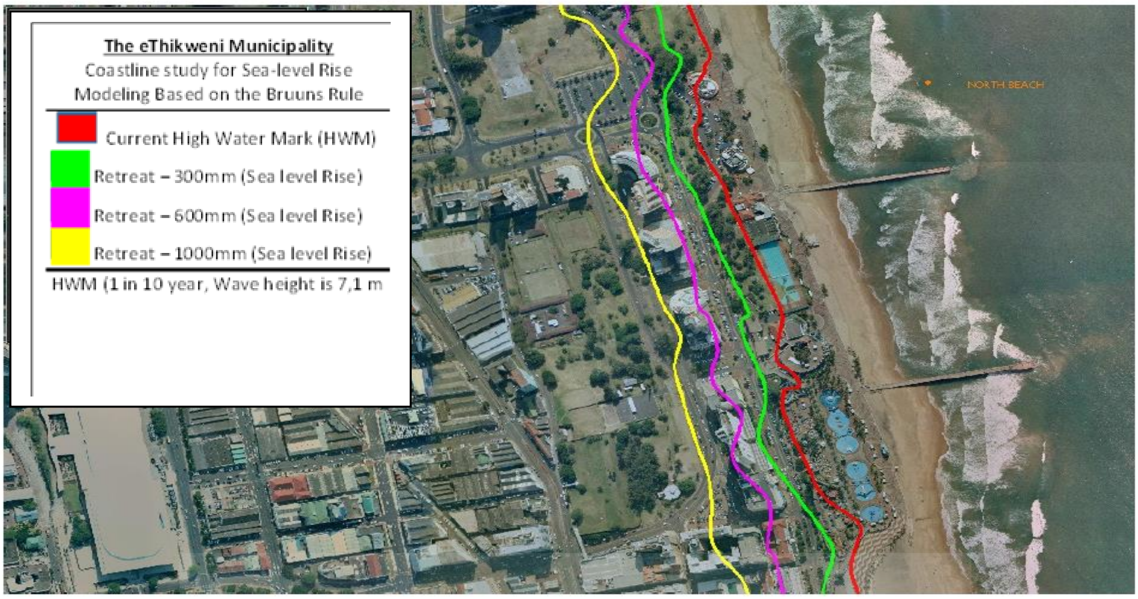


**Figure 2.2: Present and future high-water mark along Durban central beachfront**

***Source:*** *Adapted from Mather and Stretch (2012)*

In Figure 2.2, the red line represents the current high-water mark and indicates that some beachfront infrastructure is already on the seaward side of this mark. The green, purple and yellow lines indicate an increase in sea level of 300 mm, 600 mm and 1 000 mm, respectively. The yellow line clearly indicates that the high-rise buildings situated on the Durban beachfront are in danger of being below the high-water mark if the sea level rises by 1 000 mm.

## 2.7 RISING SEA LEVEL IN SOUTH AFRICA

The rise in sea level is the result of a thermal expansion of the oceans, melting of the ice caps and glaciers and an increase in the ice discharge from the ice sheets in Greenland and Antarctica (Nicholls et al., 2007).

The IPCC's predictions of sea level rise were confirmed by a study of the South African tide gauge records over the past 30 years (Theron & Rossouw, 2008). Theron and Rossouw's study confirmed the findings of an earlier study conducted by Hughes (1992) in which he predicted that the consequences of a rise in sea level will be beach erosion, flooding and inundation, saltwater intrusion and elevated coastal groundwater tables and storm damage.

In reaction to the predicted threat from climate change, the South African government demonstrated its commitment to address the risks associated with climate change by promulgating Acts such as the National Environmental Management Amendment Act 8 of 2004 (South Africa, 2004b) and the ICM Act (South Africa, 2008 & 2014), and publications such as SARVA in 2010. The purpose of the ICM Act is to manage the effect of the rising sea level on the coastal environment. The ICM Act established a coastal zone and requires that coastal local authorities delineate a CML below which the development is strictly controlled (South Africa, 2014a). Except for the environmental risk, i.e. the physical risk to property caused by acts of nature, the promulgation of the above Acts also creates legislative risk for the owners of coastal residential properties.

The effect of a rise in sea level on the South African coastline has been highlighted in studies conducted by Hughes (1992), Midgley et al. (2005), Theron, Rossouw, Barwell, Maherry, Diedericks and De Wet (2010), Umvoto Africa (2010a) and Van Ballegooyen, Theron and Wainman (2003). These studies all indicate that the greatest current risk from the rising sea level and extreme events would be to sheltered environments along the coast such as estuaries, coastal wetlands, tidal inlets and marinas (Wigley, 2011).

In South Africa, the larger estuaries are prone to have some residential development on their shoreline (Burns, Connell, Makhanye, Monteiro, Morant & Taljaard, 1999). According to Wigley (2011), the flooding and inundation of coastal areas are globally seen as one of the biggest impacts on the built environment, coastal populations and ecosystems.

The provincial government of the Western Cape's Department of Environmental Affairs and Development Planning: Strategic Environmental Management commissioned a study entitled "Sea Level Rise and Flood Risk Assessment for a Select Disaster Prone Area along the Western Cape Coast". Umvoto Africa (2010a) prepared the study. Blake (2010), the author of the report in which the rising sea level and flood risk in the Eden District Municipality was examined, confirmed that the coastal area between Mossel Bay to Nature's Valley is susceptible to the rising sea level. He confirmed the findings of Hughes (1992), Theron and Rossouw (2008) and Midgley et al. (2005) that Mossel Bay to Nature's Valley in the southern Cape region is one of the most vulnerable coastal areas in South Africa.

## 2.8 RISK OF RISING SEA LEVEL IN SOUTH AFRICA

The risk inherent in the changing climate is complicated by its slow onset. Although the impact of climate change is visible in many areas, the greater part of the outcomes is still to appear. There are two types of climate change risk inherent in the rising sea level that will have an influence on coastal residential property owners in future. The first is the environmental risk to property that can be attributed to the rising sea level, namely storm surges, greater tides, flooding, erosion and groundwater contamination (Cartwright, 2008). The second risk is a consequential risk created by legislation to manage the potential rise in sea level (South Africa, 2008).

In an attempt to deal with the changing climate, the South African government has conducted a number of studies and promulgated legislation to specifically deal with the risk of the changing sea level.

### 2.8.1 Climate change risk

In 2010, the Department of Science and Technology published the South African Risk and Vulnerability Atlas (SARVA) (South Africa, 2010). According to the then Minister of Science and Technology, the purpose of the publication was to provide a condensed overview of areas sensitive and vulnerable to various kinds of risks, disasters and climate-related impacts.

The content of SARVA is arranged in eight different topics: the future climate, socio-economic and settlement, water resources, agriculture, human health, biodiversity and commercial forestry, land use and coastal areas.

Projections regarding the future climate predict an increase of more than three degrees in the median temperature over the central and northern interior of the country and two degrees along the coast by the end of the century (South Africa, 2010). The effect of an increase in extreme events, droughts and heavy rainfall will become noticeable as saltwater intrusion takes effect, run-off and erosion increase, agricultural production and profits decrease and international water conflicts arise (South Africa, 2010).

The impact of climate change on human health is related to extreme weather events such as heatwaves, floods, cyclones, storm surges and droughts and also risks due to an increase in pollens, spores and moulds (South Africa, 2010). These factors will have an influence on future land use patterns such as urbanisation. Urbanisation leads to the loss of habitats and destruction of ecosystems, for example the reclamation of wetlands for the construction of housing projects. The cumulative impact of land use and climate change can result in crop failure due to drought and inundation of the coastline due to a rising sea level (South Africa, 2010).

The changing climate will affect water temperature, salinity and currents of the oceanic region along the South African coast and the coastline and bordering areas inland (South Africa, 2010). Increased water temperature will lead to an increase in the sea level through thermal expansion, melting of glaciers and the poles. According to Meier and Wahr (2002), the increase in the global sea level is based on data collected by the Permanent Service for Mean Sea Level from tide gauges around the globe. Globally the increased water temperature of the oceans is a result of the increasing global mean temperature (Church et al., 2013). The increasing global mean temperature also affects the melting rate of glaciers and the poles, thus adding to the rising sea level.

It is predicted that this will create storms that are more frequent and more intense, a change in rainfall patterns, sediment fluxes from rivers and coastal erosion in Southern Africa (Theron et al., 2010). The rising sea level will increase the distance waves will reach inland, thus threatening infrastructure. It is therefore necessary to adjust the current setback lines to provide for the expected wave run-up and erosion (South Africa, 2010).

### 2.8.2 Consequential risk

In 2008, the ICM Act dealing specifically with the projected influence of the rising sea level on coastal areas was promulgated to govern environmental affairs in South Africa. In terms of the Act, all new developments are subject to the completion and approval of an environmental impact assessment (EIA). The compulsory completion of EIAs has not only complicated the development process, but has also increased the lead-time before the actual construction of developments can commence.

The National Environmental Management: Integrated Coastal Management Act 24 of 2008 as amended by Act 36 of 2014 specifically deals with the South African coastal areas. It contains three sections of concern regarding investments in coastal property. The first section relates to the position of the high-water mark (section 14(5) of the Act). The section provides as follows: '*If the high-water mark is landward of a straight line boundary of a coastal land unit when the Act took effect, or the high-water mark moves landward of the straight line boundary of a coastal land unit due to the erosion of the coast, sea-level rise or other causes, the owner of that land unit – (a) loses ownership of any portion of that coastal land unit that is situated below the high-water mark to the extent that such land unit becomes coastal public property; and (b) is not entitled to compensation from the state for that loss of ownership, unless the movement of the high-water mark was caused by an intentional or negligent act or omission by an organ of state and was a reasonably foreseeable consequence of that act or omission'* (South Africa, 2008).

Section 15(1) and (2) provides as follows: '*No person, owner or occupier of land adjacent to the seashore or other coastal public property capable of erosion or accretion may require any organ of state or any other person to take measures to prevent the erosion or accretion of the seashore or such other coastal public property, or of land adjacent to coastal public property, unless the erosion is caused by an intentional act or omission of that organ of state or other person … No person may construct, maintain or extend any structure, or take other measures on coastal public property to prevent or promote erosion or accretion of the seashore except as provided* *for in this Act, the National Environmental Management Act or any other specific environmental management Act'* (South Africa, 2008).

Although these sections may in the future have sombre legal consequences for investment in property along the South African seashore, section 25 has an immediate effect. In terms of section 25, regulations must be published to '*establish or change coastal management lines – (a) to protect coastal public property, private property and public safety; (b) to protect the coastal protection zone; (c) to preserve the aesthetic values of the coastal zone; or (d) for any other reason consistent with the objectives of this Act; and (1A) An MEC may, in regulations published in the Gazette, prohibit or restrict the building, erection, alteration or extension of structures that are wholly or partially seaward of a coastal management line.'* (South Africa, 2008).

In a study conducted by Kavonic (2013) she found that the delineation of new management lines can have a positive and negative effect on the wider community in a specific area. Once the management lines are drawn, properties on the seaward side of the coastal setback line will lose value, while inland properties above the CML will become the new beachfront properties and increase in value (Kavonic, 2013).

## 2.9 SUMMARY



The literature pertaining to the changing climate globally and locally was assessed and reported with specific reference to the rise in sea level and the risk of this to coastal residential properties in Sedgefield, South Africa.

Although some of the climate change sceptics lay the cause of climate change at the door of natural inconsistency in the weather or geologic time, others blame fudged data or inadequate modelling or claim that there is just no evidence of climate change at all.

It is generally accepted that the IPCC represents the mainstream view regarding the changing climate and therefore for the purpose of this study the IPCC's definition of climate change will be applied.

The IPCC's assessment reports are backed up by numerous scientific reports and studies published concerning the changing climate and the anticipated effect of rising sea levels. The changing sea level is an indication of the changing climate and will have socio-economic consequences for the people living close to the current mean sea level.

Changing sea level risk in South Africa has an environmental and consequential impact. The question is how these risks will affect the value of coastal residential property.

The risk created by the changing climate will entail an environmental and a consequential risk due to the rising sea level. This risk can include market risk, financial risk, capital market risk, inflation, liquidity risk, environmental risk, legislative risk and management risk normally associated with an investment in property (Appraisal Institute, 2013).

As a result of the slow onset of climate change, the risk is difficult to identify because it is currently still a prediction of something that will happen some time in the future. Bienert et al. (2008) argue that if this potential profit in the future is restricted by changes in the climate, it must be reflected in the current value.

This raises the question: does property valuers' current opinion of value reflect the future impact of the rising sea level on the value of coastal residential properties? Value, the factors that influence value and other researchers' attempts to determine the economic impact of the changing climate will be discussed in chapter 3.

# CHAPTER 3

# PROPERTY VALUERS' PARADIGM AND SEA LEVEL RISE RISK

## 3.1 INTRODUCTION

In the previous chapter, it was highlighted that climate change and the rising sea level point to major challenges for sustainable coastal property ownership. In this chapter, the effect of the rising sea level on the property valuers' paradigm will be examined to include the rising sea level and accompanying risks in the valuation process. This chapter will commence with an examination of sea level rise risk (SLRR) and residential real estate, followed by attempts made by different researchers to determine the economic impact of the changing climate with specific reference to the influence of the rising sea level. The chapter concludes with the challenges faced by valuers to include the risk created by the rising sea level and the introduction of the ICM Act 24 of 2008 and accompanying risks in the valuation process.

## 3.2 SEA LEVEL RISE RISK AND RESIDENTIAL REAL ESTATE

Homeownership is one of an individual's biggest investments and has a significant impact on an individual's post-retirement financial wellbeing (Chen, Pryce & Mackay, 2011). Although an investment in real estate is commonly seen as a long-term investment without risk (Salzman & Zwinkels, 2013), the rising sea level will have a negative impact on coastal residential properties in particular (US EPA, 2016a). Chen et al. (2011) indicate that residential property is a major source of collateral in the mortgage market and declining values can create chaos in the financial market. They insist that housing economists must include the effect of the changing climate and future flood risk on housing and financial markets.

In South Africa the Department of Environmental Affairs promulgated the ICM Act 24 of 2008:

> *To establish a system of integrated coastal and estuarine management in the Republic, including norms, standards and policies, in order to promote the conservation of the coastal environment, and maintain the natural attributes of coastal landscapes and seascapes, and to ensure that development and the use of natural resources within the coastal zone is socially and economically justifiable and ecologically sustainable …*

The promulgation of the Act initiated a process to delineate coastal setback lines to provide for the impact of the rising sea level and associated storms and storm surges on the coastal zone. The ICM Act emphasises the risk of investing in coastal residential property (South Africa, 2008). The introduction of coastal setback lines is perceived to be a sustainable method to provide for the future impact of the rising sea level (Mather, 2007; Schoonees, Lynn, Le Roux & Bouton, 2008; Theron et al., 2010).

In a study entitled '*A preliminary evaluation of the socio-economic implications of the implementation of coastal development setback lines: A case study of the Kogelberg coast in the Overberg District'*, Kavonic (2013:1) indicates that the delineation of setback lines will have a socio-economic impact on properties within the no-development zone. She submits that the rights of property owners and property values will be affected (Kavonic, 2013; Cartwright, 2008; Breetzke et al., 2012). Cartwright (2008) also suggests that the introduction of new setback lines may spearhead a decline in revenue for local authorities due to decreased property values and increase in the maintenance of infrastructure.

According to Theron (2016), the current process to delineate coastal setback lines is flawed as the setback lines are located on the seaward border of improved coastal properties. He believes that this creates a false impression that these properties are not at risk. He maintains that '*the setback line should be based on the actual coastal processes and dynamics thereby determining which areas are subject to the hazards or where the risks from the impacts due to coastal/marine hazards are unacceptably high*' (Theron, 2016:34). Although Theron (2016) draws attention to the socio-economic and legal implications if setback lines are delineated according to the actual physical processes, he does not express an opinion on how this should be dealt with.

Identifying the predicted physical impact of climate change is straightforward. However, quantifying the economic impact of climate change and the adaptation and mitigation measures is challenging, especially the impact of the rising sea level on coastal residential property.

### 3.3 ECONOMIC IMPACT OF CHANGING CLIMATE AND RISING SEA LEVEL

Stern (2007) changed the climate change debate from a debate mainly among climate scientists to an economic debate. The Stern Review highlighted the economic impact of the changing climate on the world based on a cost benefit analysis. His findings were widely criticised on three aspects, namely the discount rate he used, his handling of risk and uncertainty and the way he calculated and compared the cost and benefits (Ackerman, 2007).

Kirkpatrick (2011), citing the Queensland government Environmental Protection Authority, suggests that a cost benefit analysis in financial valuation only considers costs and benefits directly related to the return on an investment, whereas all costs and benefits, positive and negative to the broader community, are considered in environmental valuation.

According to Yohe (1991), the potential economic effect of the changing climate should be expressed in terms of time and circumstances based on the current understanding of the underlying uncertainties. He also emphasises the effect of extreme short-term events that accompany climate change. He argues that the problem at the core of decision making under conditions of long-term uncertainty is to analyse the economic value of the likely responses to the effects of global warming based on our current knowledge of the future.

The economic impact of the changing climate and specifically the impact of the rising sea level were investigated on the US California coast, as previously mentioned in chapter 1. The replacement value of property was used to estimate the economic impact of sea level rise (Heberger et al., 2009). Heberger et al. (2009:33) excluded property or land values, which were higher than replacement value. However, they agree that property and land values should be used if inundation is permanent or leads to the abandonment of property. They further found that replacement value is not suitable to estimate the cost of erosion since erosion normally results in the total loss of property and land.

In an attempt to determine the economic cost of the rising sea level King et al. (2010) found that data regarding age, character and the condition of improved properties was not readily available and they therefore valued properties at risk to flooding and erosion using a constant depreciation factor of 25%. King et al. disagreed with Heberger et al. about using a depreciated replacement value when the damages to structures are estimated and when dealing with events where land erodes. King et al. argue that the market value of land is more relevant to estimate the value of the damages to land. In their view the sales comparison approach is an ideal method to use when there are limited market sales but detailed data of site characteristics of all properties is available.

Hennecke et al. (2004) state that there is a relationship between the land value and market value of a property.

In South Africa Hughes (1992:i) was the first to examine the effects of the rising sea level on the South African coastal environment. The aim of his study was to identify the consequences inherent in the rising sea level and to find a suitable method to model the impact of the rising sea level. Hughes (1992:i) developed a coastal vulnerability index which he tested on the southern Cape coast and the KwaZulu-Natal south coast. In his research, he found that the southern Cape coast – Mossel Bay to Nature's Valley – is one of the four areas with the highest risk of being affected by the rising sea level. He identified private housing as the coastal infrastructure with the highest risk along the southern Cape coast. Although he presents his coastal vulnerability index as a quasi-economic risk rating, he does not attach a rand value to the risk rating. He was of the opinion that the selling price of at-risk properties would provide the best indication of economic loss. He did not pursue this, as he believed that it was outside the scope of his study.

Since 1992 a number of studies which considered the rising sea level were conducted and except for the two studies reported below, none of these studies examined the economic impact of the rising sea level on coastal residential real estate. Cartwright (2008) determined the consequences of the predicted rising sea level and consequential increasing storm events on the City of Cape Town. The aim of the study was to provide information which Cape Town can use to plan, prepare for and mitigate future risk from the predicted rising sea level. Cartwright explains that a common mistake often made in environmental risk analysis is to equate replacement cost with economic loss. He indicates that when environmental damage is being assessed, opportunity cost should rather be used and that opportunity cost is mostly less than financial costs.

In his study, Cartwright (2008a) quantified the economic impact of sea level rise by using the City of Cape Town's valuation roll as a basis to determine a rate per square metre for coastal land. He assumed that the average value of the affected property would decrease due to the extent of the properties that will be affected.

Although the basis used by Cartwright was market value, he altered the values by calculating averages and establishing weighted averages for land. This approach deviates from valuation theory according to which the final opinion of value should be expressed as a *'single dollar figure derived from the reconciliation of value indications stated in the appraisal report'* (Appraisal Institute, 2013:642).

A second coastal risk assessment study was conducted in 2010 to assess the risk of sea level rise and flood hazards in the Eden District Municipality (Umvoto Africa, 2010). The provincial government of the Western Cape's Department of Environmental Affairs and Development Planning: Strategic Environmental Management commissioned the study. Umvoto Africa (2010b) concluded that if an extreme event similar to the storm event that struck the KwaZulu-Natal coast in March 2007 took place, the damage or economic vulnerability could be as much as 50% of the total annual budget of the Eden District Municipality and five coastal local municipalities combined. Umvoto Africa provided no clear explanation of how they reached this assumption other than that it was based on the 2009/10 budget of the Eden District Municipality and the associated local municipalities of approximately R2, 5 billion. They did not define economic vulnerability other than to state that it was based on the total approximate economic cost in rand (Umvoto Africa, 2010).

From the analysis above, it can be concluded that there are conflicting methodologies to determine the economic impact of rising sea level on coastal property values in the literature. This indicates that there is uncertainty in literature on how to determine the actual impact of a rising sea level in terms of economic cost.

Risk associated with the changing climate is on the increase and from the studies quoted above, it is clear that there is a need to quantify this risk. The imminent risk of the rising sea levels to coastal residential property raises the question of how property valuers should attend to SLRR with the aim of providing an objective and independent opinion of value to their clients in order to reduce this risk and provide certainty in real estate transactions.

The focus of this study was therefore on investigating the predicted effect and ensuing risk of a rise in sea level on the valuation behaviour of property valuers in the coastal residential real estate market and on designing a model that can be applied by property valuers to develop an opinion of the market value of coastal residential properties in Sedgefield, South Africa.

## 3.4 VALUATION PROCESS



Yohe (1991:265) expressed the property valuer's challenge with regard to the rising sea level as follows:

> *The problem of analysing the economic value of potential responses to the effects of global climate change is a problem that lies at the heart of decision making under conditions of enormous long term uncertainty - one of ranking possible responses and evaluating their most advantageous timing on the basis of the current state of our knowledge (or ignorance) of the future.*

Bienert et al. (2008) do not specifically refer to SLRR but point out that valuers should determine the influence of climate change on the future benefits of an investment in real estate. To arrive at an opinion of the value of a specific property, a valuer applies a systematic valuation process. Harrison, Smersh and Schwartz (2001:4) believe that when residential property valuers apply the traditional property valuation and assessment procedures for assessment and mortgage purposes, the environmental risk of flood lines is not adequately considered in the property valuers' opinion of value. This raises the question whether valuers will have to change their current practice of studying past market behaviour to arrive at an opinion of market value.

To remain objective, valuers follow a systematic procedure called the valuation process. The valuation process as described in the Appraisal of Real Estate comprises eight steps; see Figure 3.1 (Appraisal Institute, 2008:113).

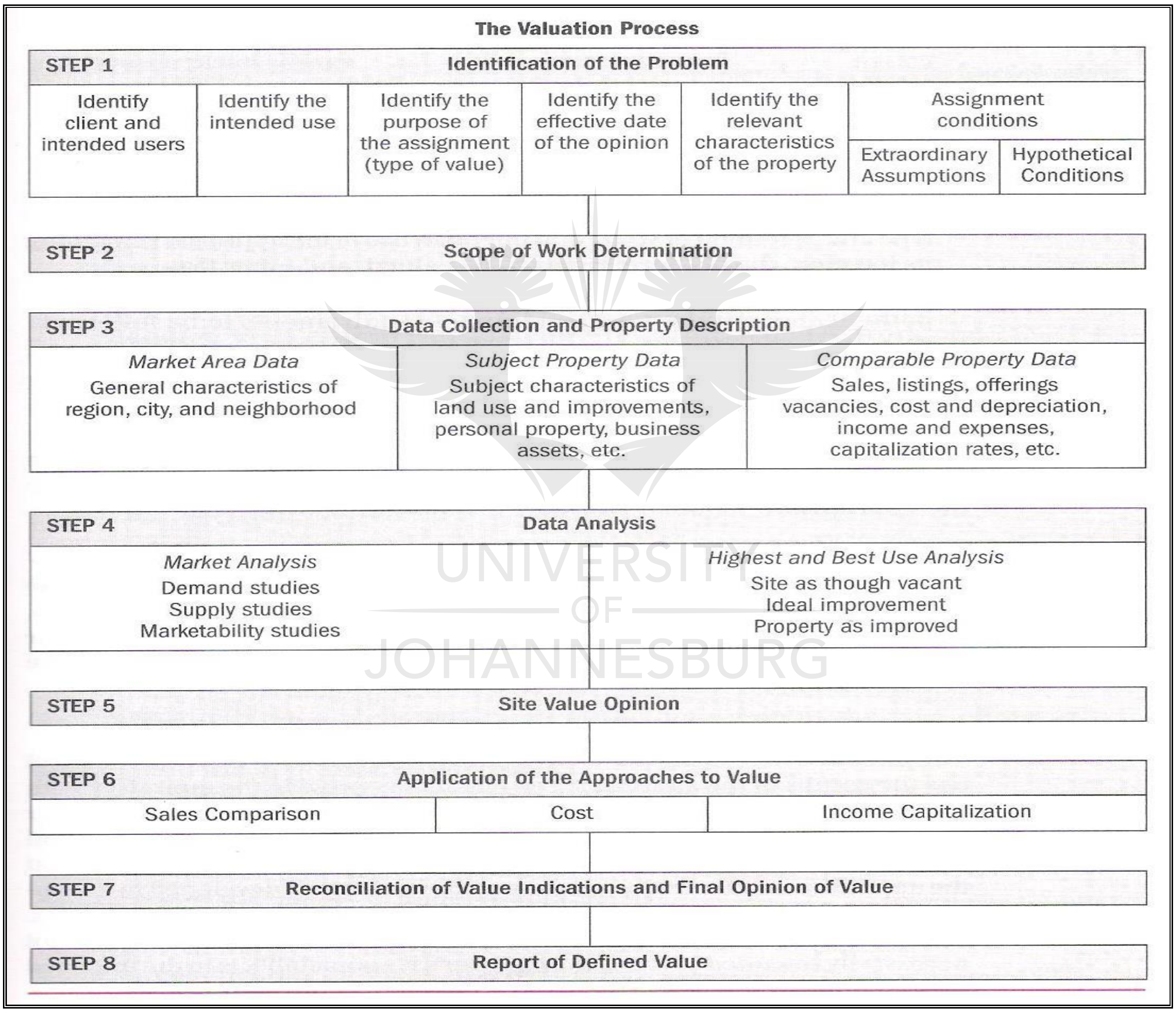


**Figure 3.1: Valuation process**

***Source:*** *Appraisal Institute (2008:113)*

The valuation process as depicted in Figure 3.1 is a guideline and well known in South Africa. The South Africa Council for the Property Valuers Profession (SACPVP) subscribes to the IVSs and all valuations conducted should therefore comply with the IVSs.

The valuation process commences when a property valuer accepts a request from a client to provide the client with an opinion of value concerning the subject property. One of the first actions taken by the property valuer is to establish the basis of value.

### 3.4.1 Basis of valuation

The IVSs define the basis of value as '*a statement of the fundamental measurement assumptions of a valuation*' (IVSC, 2014:3). They state that there are three principal categories for a basis of valuation, namely market value, investment and special value and fair value. However, they do affirm that there may be alternative bases of value that are stipulated by decree, contract or document.

The primary basis of valuation for the European Valuation Standards is market value unless the purpose of the valuation required is prescribed by law, conditions or instructions from a client, and the result must clearly state that it is not a market value (TEGoVA, 2012). The Royal Institute of Chartered Surveyors (RICS) recognises '*market value, market rent, worth (investment value) and fair value*' as a basis of valuation (RICS, 2012:29). Like the other associations, the RICS also states that valuers may base their value on other criteria if instructed by the client.

In South Africa, the SACPVP does not prescribe any type of value or basis of valuation, but section 46(1) of the Local Government: Municipal Property Rates Act 6 of 2004 (MPRA) does prescribe market value as the general basis of valuation for assessment purposes (South Africa, 2004a).

Both the RICS and the European Group of Valuers Associations (TEGoVA) have accepted the International Valuation Standards Committee's (IVSC, 2014) definition of market value. It is only the Appraisal Institute from the USA whose definition differs from the IVSC's definition. The Appraisal Institute (2015) suggests that the IVSs may be applicable, as an international standard, for certain assignments.

According to the Appraisal Institute (2015), value is an economic expression of an opinion of the worth of a property, as long as it is in agreement with a specific definition of value, for instance market value, liquidation value, or investment value. The IVSs refer to '*the estimated amount*', whereas the Appraisal Institute (2013) refers to *'most probable price, as of a specified date, in cash, or in terms equivalent to cash, or in other precisely revealed terms'*. If market value is conveyed as cash or terms equivalent to cash, a summary explaining the effect of such financing on the value must be provided (Appraisal Institute, 2013). This is contrary to the view of the IVSs that market value disregards all transaction costs and taxes (IVSC, 2013).

The SACPVP adopted the IVSs as the valuation standard. Yet some of the older South African Acts still contain definitions of market value that differ from the IVS definition of market value. For example, the MPRA just states that market value is '*the amount'* and not '*the estimate amount*' as in the IVS definition (South Africa, 2004a:24). A further difference is the last part of the IVS definition (IVSC, 2014:3) '*after proper marketing wherein the parties had each acted knowledgeably, prudently and without compulsion',* which is not included in the MPRA.

The Property Valuation Act 17 of 2014 (South Africa, 2014b:4) uses the IVS definition of market value:

> *market value means the estimated amount for which the property should exchange on the valuation date between a willing buyer and a willing seller in an arm's length transaction after proper marketing and where the parties had each acted knowledgeably, prudently and without compulsion*

The adoption of the IVSs as minimum standards introduced, among other things, a requirement to include any adverse conditions, i.e. *'the impact of any events foreseeable at the valuation date on the probable future value of the security during the loan period'* (IVSC, 2014:47). The changing climate and specifically the rising sea level is an adverse event, which will have an impact on the future value of coastal residential real estate (Bienert et al., 2008).

### 3.4.2 Market value

Market value is created primarily by four interdependent factors, namely utility, scarcity, desire and effective purchasing power (Appraisal Institute, 2013). Social, economic, governmental and environmental influences also affect real estate markets (Kucharska-Stasiak & Źróbek, 2015). The market value of a property is further affected by its location, highest and best use (HBU) and the physical characteristics of a property (Kropp, 2012). The HBU of a property takes cognisance of all legal, physical and financial constraints in order to determine the most profitable use of such property (Appraisal Institute, 2013). The location refers to the influences on a property from the micro and macro environment it is situated in (Appraisal Institute, 2013). According to Wight and Ghyoot (2005), location is an environmental risk. They argue that due to the immovable nature of property, changes in its environment can be positive or negative. As a whole, these changes are uncontrollable (Wight & Ghyoot, 2005:137). An example is Kropp's claim (2012) that the market value of properties located on a flood plain will be affected by the risk of recurring floods.

### 3.4.3 Effect of flood risk on market value

Kropp (2012) indicates that flooding has a negative effect on market value and argues that flood risk should be included in the valuation process. This argument is supported by Hill (2015), who also indicates that flooding risk due to the rising sea level will become decidedly relevant in the future.

The effect of flooding on the value of residential property is well researched; this is in contrast with the effect of the rising sea level on real estate values, which is poorly researched (Bélanger & Bourdeau-Brien, 2016; Lamond et al., 2009; Hallstrom & Smith, 2005; Eves & Brown, 2002).

The majority of the studies researching the effect of flooding on real estate values applied hedonic price modelling. The results indicate a decrease of between 3.8% and 11% in real estate values due to flooding (Bin et al., 2008; Pope, 2008; Bin & Kruse, 2006; Bin & Polasky, 2004; Troy & Romm, 2004). Hedonic price modelling is used to establish the inherent value of each of the characteristics of a property in order to estimate a transaction price (Manson, 2009). The application of hedonic modelling must be considered in terms of its characteristics. According to Manson (2009), hedonic price modelling is generally suitable when there are few transactions in a market and typically for non-income-generating properties such as residential real estate. While Du Preez and Sale (2014) argue that hedonic price modelling can be used to determine real estate value, the absence of the structural characteristics of properties on municipal valuation rolls in South Africa requires that the properties will have to be physically inspected to apply this model.

Bélanger and Bourdeau-Brien (2016) found that the value of houses located inside flood zones was 2% lower than that of houses outside of the flood zone. They felt that an econometric model was more appropriate for their study and that they had to abandon the standard hedonic price modelling due to the difficulty of obtaining individual property characteristics when they expanded the geographic coverage of their study.

Lamond et al. (2009) and Hallstrom and Smith (2005) used repeat sales to determine the effect of flooding on house prices. They established that flooding temporarily reduced the value of affected properties. The temporary reduction in value was, however, recovered within three years (Lamond et al., 2009). Hallstrom and Smith (2005) cross-checked their repeat sales model with a hedonic pricing model to research the market response to flood risk information. They estimated that Hurricane Andrew reduced the selling prices of properties located in the special flood hazard areas (SFHAs) by 19%.

Eves (2002) researched the influence of a major flood on the value of residential real estate. Two similar areas, one at risk of being flooded and the other not at risk of being flooded were statistically compared. The research confirmed that the value of properties at risk of being flooded is lower than similar properties in the area that are not at risk. Eves (2002) submits that once the risk of being flooded has been taken into account, the properties will appreciate at the same rate.

Apart from a statistical analysis, Eves and Brown (2002) conducted a survey of chartered surveyors and chartered real estate valuers in all flood-prone areas in

England. The purpose of the survey was to ascertain and express the effect of flooding and flood damage. They concluded that:

- there is a relationship between the magnitude of a flood and reduced residential real estate values;
- chartered surveyors, insurers and financiers are better informed regarding the effect of flooding on residential real estate than residential real estate purchasers;
- the unavailability of property insurance and property finance negatively affects residential real estate values;
- flood defences have a positive impact on residential real estate markets; and
- the provisioning of flood defences is seasonal.

The results of these studies reveal that flood events and being located on a flood plain have a negative effect on the value of residential real estate. The effect of flooding is complicated as some studies found that the decrease in prices is only temporary (Lamond et al., 2009; Hallstrom & Smith, 2005; Eves, 2002).

### 3.4.4 Valuation of at-risk property

A valuation is at best an estimate of value based on the assumptions accepted by the valuer (Kucharska-Stasiak, 2013). Aliyu, Bello, Kasim and Martin (2014) submit that risk and uncertainty are built into the valuation process because the valuer cannot identify all the future influences on the value of a subject property.

The general requirements of the valuation process are outlined in IVS 101 Scope of Work (IVSC, 2013:21). According to IVS 101, the intended purpose of a valuation determines the suitability of a property valuer's opinion of value and the effort the valuer put into the development of the opinion of value. The property valuer's opinion of value is therefore influenced by assumptions and special assumptions which apply to the property being valued.

In terms of the IVSs any assumption or special assumption must be in writing and property valuers are obliged to make only reasonable and relevant assumptions

(IVSC, 2013). This is confirmed by the RICS when they declare that when a valuer can assume something is true and does not need to investigate it, it is called an assumption. A special assumption is something that might come true in the future but is currently, at the date of valuation, not true (RICS, 2012).

IVS 230 Real Property Interests introduce additional requirements that property valuers must comply with when they develop an opinion of value regarding real property interests (IVSC, 2013:35):

*the following matters shall be considered:*

- *The evidence required to verify the real property interest and any relevant related interests,*
- *The extent of any inspection,*
- *Responsibility for information on the site area and any building floor areas,*
- *Responsibility for confirming the specification and condition of any building,*
- *The extent of investigation into the nature, specification and adequacy of services,*
- *The existence of any information on ground and foundation conditions,*
- *Responsibility for the identification of actual or potential environmental risks,*
- *Legal permissions or restrictions on the use of the property and any buildings*

The valuation process recommended by the IVSs therefore requires property valuers to consider actual or potential environmental risks, i.e. SLRR, when they develop an opinion of value of at-risk properties.

IVS 310 Valuation of Real Property Interests for Secured Lending requires that valuation reports for secured lending should include an assessment of the collateral provided by the real property interest over the life of the loan (IVSC, 2013). Section 7(d) and (e)(iii) of IVS 310 suggests that property valuers should include comments regarding the impact of events foreseeable at the date of valuation, i.e. the impact of the rising sea level and if the market value will not be realisable at a future date.

The IVSs focus on the valuation process and highlight areas of concern without any explanation to clarify the concerns. Property valuers, as knowledgeable witnesses in a specific real estate market, are therefore obliged to take all the potential future changes, i.e. SLRR, into account when they develop an opinion of value (TEGoVA, 2016).

### 3.4.5 Valuation certainty, uncertainty and risk

A valuation is an account of a property valuer's opinion of value based on the evidence collected pertaining to a subject property during the valuation process. Valuation certainty is determined by a property valuer's professional skills, the clarity of the instruction received and the quality of the evidence collected (TEGoVA, 2016).

Valuation uncertainty can be triggered by the inexperience of the property valuer, the nature of the assignment, the market, the valuation method and required input data (IVSC, 2010).

According to French (2007:3), uncertainty in property valuation is a common problem. He defines uncertainty as '*anything that is not known about the outcome of a venture at the time when the decision is made*' and risk as '*the measurement of a loss identified as a possible outcome of the decision'*. French argues that uncertainty is created by insufficient inputs, i.e. inadequate knowledge and/or evidence. He claims that if a probability is assigned to an input variable, a range of outcomes become possible. Value is thus an estimate and not a fact (RICS, 2012).

EGVA points to the fact that once a property has been valued, the value will be exposed to future risks. These risks include physical changes, for example floods or rising sea levels, macro-economic, market and legislative changes (TEGoVA, 2016). Aliyu et al. (2014) maintain that uncertainty and risk should be an integral part of the valuation process because prevailing and future influences are often overlooked by property valuers. This is emphasised by Mallinson and French (2000) in their contention that there is a great deal of misunderstanding regarding the articulation of uncertainty in valuation due to the absence of a standardised approach.

### 3.4.6 Real estate markets and environmental risks

According to Farber (1998), economists advocate that real estate markets are rational and efficient as property values are perceived to respond to real risks such as floods. Farrow and Scott (2013) argue that the possibility of an environmental risk such as flooding will impact on the value of property.

The IVSs refer to environmental risk but do not explain what is meant by actual or potential environmental risks, nor do they propose a methodology to determine the quantum of the environmental risk. According to the RICS (2015:9), key environmental risks are not only the '*increasing incidence of extreme weather events, the impact of rising sea level and temperature changes*', but also the tendency of governments to reduce the force of climate change through legislation. Wyatt (2013) contends that the impact of environmental risk, specifically from floods and the rising sea level, and the resulting changes in legislation must be taken into account in property valuations. Cradduck (2014) argues that the explanation of '*potential environmental risks'* in IVS 230 should include examples of flood and other water risks (IVSC, 2013:35).

Environmental risk is defined by the Appraisal Institute (2013:159) as risk that *'the market value of a property will be affected by its physical environment'* and indicate that it will be influenced by 'a*cts of nature such as earthquakes and weather conditions'*. Eves and Brown (2002) also indicate that the changing climate is increasing the environmental risk to real estate.

Although there is an awareness of climate risk, there is an overall failure to understand the risk (Cradduck, 2014). Cradduck and Teale (2014) explain that this to can be due to the usually prolonged interval between, for instance, flood events. Cradduck (2014) postulates that legislation to mitigate environmental risk can influence the market value and insurability of properties identified as being at risk. This presents valuers with two duties: to identify the environmental risk and to communicate this risk in their valuation report.

### 3.4.7 Environmental risk (changing climate and rising sea level) and real estate value

Internationally there is a dichotomy between researchers regarding the impact of SLRR on the value of coastal real estate. Sheehan (2012) states that the rising sea level has hardly any negative effect on coastal real estate values. In contrast, Bin, Kruse and Landry (2008), Pope (2008), Bin and Kruse (2006), Bin and Polasky (2004) and Troy and Romm (2004) observe a decrease of between 3.8% and 11% in coastal real estate values.

Bin and Kruse (2006) argue that the difference in coastal real estate values can be attributed to the value of real estate located on the shoreline being higher than that of real estate located within a coastal flood zone but away from the shoreline. They found that the difference can be between 5% and 10%. Turnbull et al. (2013) maintain that real estate located closer to the shoreline achieves higher selling prices. Bin and Kruse (2006) contend that the rising sea level and coastal erosion will present a risk to coastal communities' investment in real estate in the future.

A secondary concern is the temporary effect and irregular occurrence of flood events due to the rising sea level. Atreya, Ferreira and Kriesel (2013), Lamond et al. (2009), Hallstrom and Smith (2005) and Eves (2002) point out that the value of affected properties is temporarily reduced in the event of a flood. The interval between flood events may or may not influence market participants' awareness of environmental risk (Cradduck, 2014).

Cradduck (2014) argues that although the environmental risk may not affect a subject property's current value, the possibility of such environmental risk should be included in the property valuer's report.

Coastal residential real estate's exposure to SLRR will become noticeable with the introduction of development setback lines along the South African coastline. Roets and Duffell-Canham (2009) identify three zones along the SA coastline, which should not be developed: primary and secondary dunes on the shoreline, below the 1-in-100-year flood line and below the 5 m contour on estuaries.

## 3.5 NATIONAL ENVIRONMENTAL MANAGEMENT: INTEGRATED COASTAL MANAGEMENT ACT, 2008

### 3.5.1 Provisions of the ICM Act

In South Africa the ICM Act will have an impact on property valuers' practice when they determine the market value of coastal residential properties (South Africa, 2014a).

In terms of section 16 of the ICM Act, the coastal protection zone includes all land units which are fully or partially situated within 1 000 m from the high-water mark in agricultural areas and 100 m in urban areas (South Africa, 2008). Land units fully or partially situated in a coastal wetland, lagoon or lake, private property below the high-water mark and property below the 1:100-year flood line are also included (South Africa, 2008).

There are three other sections in the ICM Act that are of special importance, as their implementation will have a negative influence on the market value of coastal residential property, namely sections 14, 15 and 25. Section 14(b) provides that no person *'may replace the high-water mark curvilinear boundary with a straight line boundary in terms of section 34 of the Land Survey Act'* and section 14(c) states the following (South Africa, 2014a):

> *If the high-water mark is landward of a straight line boundary of a coastal land unit when the Act took effect, or the high-water mark moves landward of a straight line boundary of a coastal land unit due to the erosion of the coast, sea-level rise or other causes, the owner of that coastal land unit –* [subsection (5)(a)] *loses ownership of any portion of that coastal land unit that is situated below the high-water mark to the extent that such land unit becomes coastal public property; and (b) is not entitled to compensation from the State for that loss of ownership*

Section 15(2) (South Africa, 2014a) states:

*No person may construct, maintain or extend any structure, or take other measures on coastal public property to prevent or promote erosion or accretion of the seashore except as provided for in this Act, the National Environmental Management Act or any other specific Environmental Management Act*

Section 25 requires the delineation of a CML in order to 'demarcate *an area within which development will be prohibited or controlled in order to achieve the objectives of this Act*' (South Africa, 2014a). Section 25(1)(a) compels the Member of the Executive Council (MEC) responsible for the implementation of the ICM Act in coastal provinces to delineate CMLs by means of a notice in the Gazette (South Africa, 2014a). The MEC may publish regulations that '*prohibit or restrict the building, erection, alteration or extension of structures that are wholly or partially seaward of a coastal management line'* (South Africa, 2014a).

The consequences of the ICM Act and specifically the sections referred to above are far reaching and will have a negative impact on the future value of coastal residential properties in South Africa.

### 3.5.2 Application of ICM Act in Western Cape, South Africa

The Western Cape provincial government initiated the process of establishing CMLs in 2010. They completed the delineation for the West Coast District, City of Cape Town and the Overberg District and are preparing the draft CMLs for the public participation process. The process to establish a CML for the Eden District started in 2016 (Bekko, 2016).

The delineation projects culminated in what can be called '*an overlay zoning based regulatory scheme*' (Van Weele, Breetzke & Steenkamp, 2015). The scheme contains four distinct elements:

- A **coastal risk assessment** for **20-, 50- and 100-year horizons**
- A **development limit** or CML
- Risk-based **overlay zones** and accompanying **development parameters** to be used in **town planning schemes**

- The demarcation of the **coastal protection zone** to broadly identify the coastal area for planning purposes.

The coastal risk assessment horizons are indicated in Table 3.1.

**Table 3.1: Coastal risk assessment horizons**

| Risk | Storm events | Rise in sea-level |
|---|---|---|
| Current | 1:10 year | 0 cm |
| Short term | 1:20 year | 20 cm |
| Medium term | 1:50 year | 50 cm |
| Long term | 1:100 year | 100 cm |

***Source:*** *Van Weele et al. (2015)*

The coastal risk assessment horizons are based on the assumptions indicated in Table 3.1 as well as topographical maps, aerial photographs, bathymetric, offshore and inshore wave height information (Van Weele et al., 2015). The risk projections mentioned in Table 3.1 are used as the basis for the delineation of the CML prescribed in the ICM Act.

Figure 3.2 illustrates the impact of the proposed coastal setback lines in the Overberg District before the amendment of the ICM Act in 2014 and the introduction of the CML (Van Weele et al. 2015).

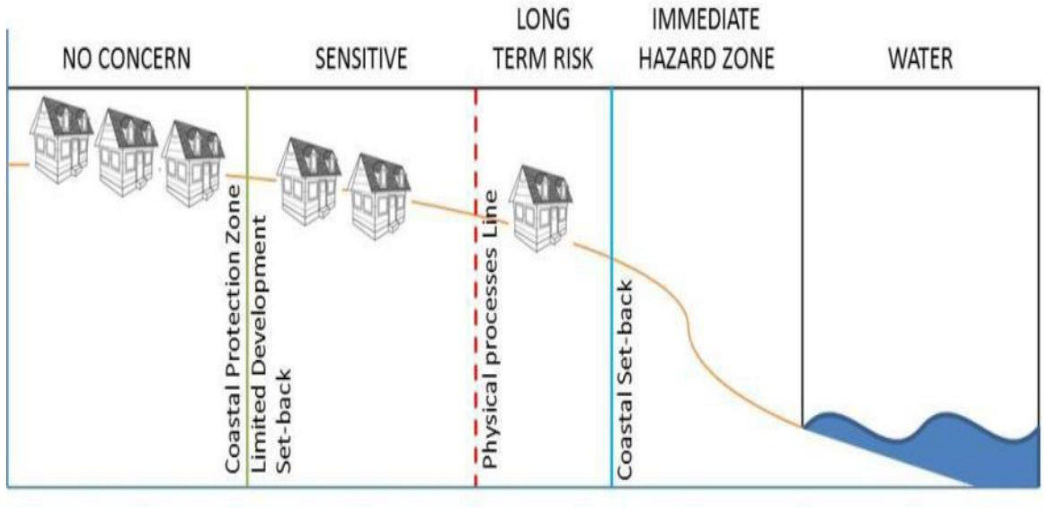


**Figure 3.2: Overberg District coastal setback lines**
***Source:*** *Van Weele et al. (2015)*

The illustration in Figure 3.2 indicates the different risk or hazard zones. The immediate hazard zone is the zone immediately above the high-water mark and will be affected by the rising sea level over the current (1:10-year) to short term (1:20-year). The long-term risk zone is exposed to the effects of the rising sea level in the short (1:20-year) to medium term (1:50-year). The sensitive zone will be vulnerable over the long term (1:100-year).

Van Weele et al. (2015) maintain that the objective of the CML is to manage coastal development and not to influence prevailing development rights. They found that there were long stretches of developed coastal land in the Overberg District which encroached into the hazard zone as indicated by the CML; see Figure 3.2.

Figure 3.3 indicates the proposed CML and different risk zones.

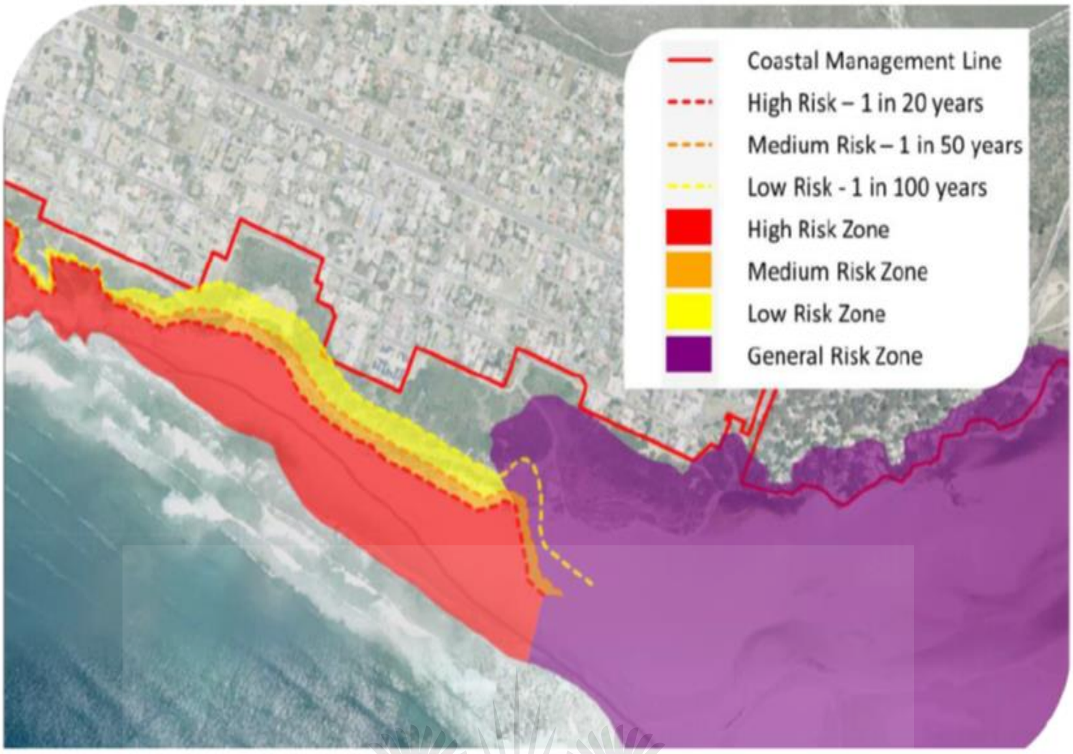


**Figure 3.3: Example of a CML and risk zones**

***Source:*** *Van Weele et al. (2015)*

Figure 3.3 illustrates the CML (red line) drawn on the seaward cadastral boundary of existing land units with development rights in order not to affect existing development rights (Van Weele et al., 2015).

Drawing the CML on the cadastral boundary of coastal land will create an illusion that coastal real estate will not be affected by SLRR (Theron, 2016). The purple area on the bottom right in Figure 3.3 indicates the opposite.

Van Weele et al. (2015) augment the CML with overlay zones as shown in Figure 3.4.


**Figure 3.4: Example of application of risk zone overlays as part of local municipal zoning scheme**

***Source:*** *Van Weele et al. (2015)*

The purpose of the overlay zones is to enhance existing town planning regulations and assist with the management of the coastal zone. In Figure 3.4, the red line represents the CML drawn on the seaward cadastral border of seafront real estate. The yellow area, which overlays the red line in places, represents the low-risk overlay zone or 1:100-year flood line (Van Weele et al., 2015). This clearly illustrates Theron's view (2016) that the CML drawn on the seaward cadastral border creates an illusion of the SLRR.

Real estate situated on the banks of estuaries is exposed to risk fashioned by the dynamics of a specific estuary and is less affected by wave impact but more by inundation (Van Weele et al., 2015). Figure 3.5 indicates the designated risk zones for estuaries.

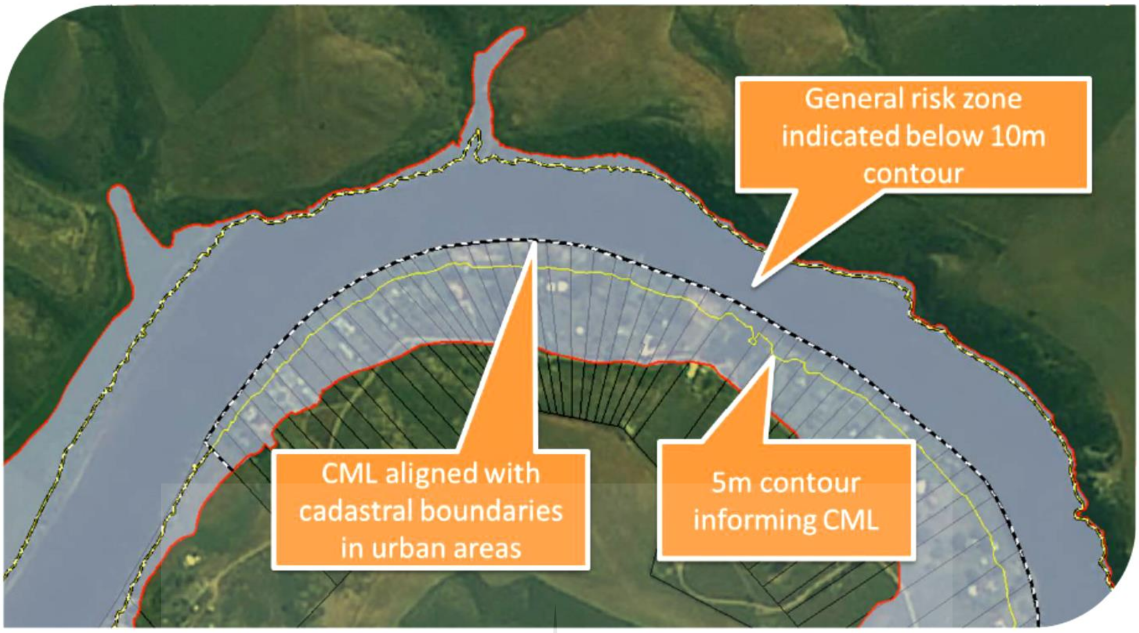


**Figure 3.5: Example of risk zone designated for estuaries**
***Source:*** *Van Weele, et al. (2015)*

Van Weele et al. (2015) applied a general risk zone below the 10 m amsl contour around estuaries; see Figure 3.5. The red line (CML) in Figure 3.5 indicates the 10 m above sea level line and the yellow line the 5 m above sea level line. The dotted black and white line represents the CML drawn on the cadastral boundaries of real estate situated on an estuary (Van Weele et al., 2015), thus on the estuary side of the 5 m above sea level line. Figure 3.5 shows that SLRR will have a much bigger impact on real estate situated on an estuary. On estuaries the 1:50-year and 1:100-year flood lines are established at 5 and 10 m amsl, respectively (Van Weele et al., 2015). A CML on the cadastral boundary of real estate on the banks of an estuary will therefore create a much bigger skewed impression of SLRR.

## 3.6 THE VALUER'S CHALLENGE

Although the changing climate does not necessarily challenge the property valuer's paradigm, it creates a challenge for valuers, especially with regard to the HBU analysis of coastal residential properties.

It is acknowledged that risk and uncertainty will be encountered in the valuation process when property valuers fail to identify all the current and future impacts on the value of a subject property (Aliyu et al., 2014). Coastal residential properties have a number of distinctive features (proximity to the shoreline, height above sea level and located within the coastal protection zone) that distinguish them from other residential properties but are also exposed to environmental risk or SLRR. Property valuers must take these features and risks into account when they conduct valuations of coastal residential properties.

The valuation process requires that property valuers perform an HBU analysis of a subject property. In the HBU analysis the property valuer applies four tests, namely whether the HBU of the subject property is legally permissible, physically possible, financially feasible and maximally productive (Appraisal Institute, 2013).

Although the introduction of a CML by the Western Cape government in accordance with the ICM does not change the current zoning of a subject property, it adds additional criteria to the current zoning. Van Weele et al. (2015) applied the following principles in the development of the proposed CML:

- *Legal development with existing rights (including zoning) must be allowed to proceed as long as public (i.e. government) liability and the quality of the coastline are not compromised*
- *Management controls/development parameters must allow for private acceptance of liability*
- *Controls must allow for discretion in decision-making by authorities based on appropriate motivations and information*
- *Provision must be made for areas where the local municipalities propose growth, as long as the development proposals are responsive towards coastal risk and ICM Act principles*
- *Coastal defences, if constructed, must be constructed and managed in an integrated manner and in accordance with legislative requirements*
- *Delineation must avoid the uncertainties surrounding the position of the [high-water mark]*
- *Management control must recognise that 'land use' and physical activities are distinct*

Althouh the delimitation of the CML in the Eden District started in 2016 it is still in process.

The Western Cape Province has four regions that border on the sea, namely the West Coast, City of Cape Town, Overberg and the Garden Route. The delineation of the CMLs for three of the four regions, namely the West Coast, Cape Town and Overberg, has been concluded. The researcher therefore accepts that the same principles will be applied for the delineation of the CMLs for the fourth region, i.e. the Garden Route.

If the practice of drawing the CML on the seaward or estuary side cadastral border of land units continues, it will create a skewed perception of the environmental risk to which the property is exposed (see Figure 3.5 above) (Theron, 2016; Pryce, Chen & Galster, 2001). Theron (2016:34) is of the opinion that the CML should be based on actual coastal processes and dynamics as the current practice of drawing the CML on the seaward or estuary side cadastral border of land units can create an incorrect assumption that a property is not at risk. Property valuers therefore cannot rely on the CML to determine if a subject property is at risk of being exposed to an environmental risk, which will affect its HBU.

Section 25(b) of the ICM Act specifies that the MEC may '*prohibit or restrict the building, erection, alteration or extension of structures that are wholly or partially seaward of a coastal management line*' (South Africa, 2014a). Property valuers will have to confirm if the MEC issued a prohibition or restriction as contemplated in section 25(b) when a subject property is fully or partially seaward of the CML. Such an order will severely affect the potential of that property and diminish any future value.

The question property valuers will have to answer is whether at-risk real estate should be valued as a wasting asset whose value depreciates over time until it has no remaining value. In addition, how should they treat improvements to at-risk properties that are still usable and in need of municipal services?

A municipality normally provides these services and charges service fees and property rates. The MPRA does not allow municipalities to impose property rates on properties below the high-water mark (South Africa, 2004b). If the high-water mark shifts, which is very likely due to the rising sea level, it will result in a loss of revenue for coastal municipalities.

Residential property is also an important source of collateral, providing additional security for mortgage bonds approved by financial institutions (Wight & Ghyoot, 2005; Pryce et al., 2001). Eves (2002) argues that when property valuers develop an opinion of value intended for at-risk property for financial institutions, the degree of flooding and time since the last flood should be stated.

The IVSs (IVSC, 2013:47) require that '*the impact of any events foreseeable at the valuation date on the probable future value of the security during the loan period*' must be included in the property valuer's report. Eves (2002) maintains that a condition to granting a mortgage to finance the purchase of a residential property is subject to the ability to insure the subject property. According to Bin, Kruse and Landry (2008), market participants use insurance premiums as an indication of the level of risk to which a property is exposed. Pryce et al. (2001) argue that an increase in insurance premiums to cover the full risk of a hazard is an effective indication of risk. According to a Department for Environment, Food and Rural Affairs report, insurers in the UK do not guarantee that they will provide insurance cover for properties situated on a flood plain (Risk & Policy Analysts Ltd, Watsons & University of Newcastle, 2009).

Chivers and Flores (2002) claim that the majority of purchasers living on a flood plain in Colorado were unaware of the flood risk and insurance rates when they purchased the property. Wozniak, Davidson and Ankersen (2012) also found that new property owners only became aware of detrimental environmental risks such as beach erosion, winter storms and sea turtle nesting restrictions after they had purchased a property.

In Australia, property situated on a flood plain cannot be insured against flood damage (Cradduck & Teale, 2014; Eves, 2002). This has a negative impact on the financing of property (Eves, 2002).

A similar situation exists in South Africa, where financial institutions are not willing to grant a mortgage without insurance. Insurers are reluctant to insure properties below the 1:50-year flood line or closer than 100 m to the water (Koekemoer, 2016; Bin et al., 2008).

According to Lausberg (2012), real estate requires a distinctive methodology to analyse risk. He argues that the identification of the risk and how to measure and report it should be addressed in the methodology.

The purpose of a valuation is to determine the present value of future net benefits (Mooya, 2016; Bienert et al., 2008; French & Gabrielli, 1994). The future net benefits of coastal residential properties will be affected by the changing climate.

The impact of the rising sea level relies on predictions of what might happen in the future, either in the short or long term. Since predictions of rising sea levels are based on models which vary considerably, this creates uncertainty for property valuers because they can no longer rely on the past to provide a perspective for the future. Aliyu et al. (2014) are of the opinion that the property valuation profession will benefit if the RICS, as suggested by Mallinson and French in 2000, to '*establish an acceptable method by which uncertainty could be expressed*'. The environmental risk (rising sea level) and the delayed implementation of the ICM Act create uncertainty.



## 3.7 SUMMARY

It is generally accepted that homeownership is the single most important long-term investment an individual will make. However, such a decision is complex as it includes emotion on the one hand and rational awareness of risk on the other. The promulgation of environmental management legislation by the government adds to the risk that potential investors in coastal residential properties should consider.

The Stern Review highlighted the economic impact of the changing climate and changed the debate from a climate science to an economic debate. Several scientists have attempted to quantify the economic impact of the rising sea level on housing infrastructure in specific locations. The result has been mixed. In one study, the researchers used the replacement cost of buildings to arrive at a value, yet in another study, property at risk to flooding and erosion was depreciated by 25%, and researchers in Australia used only the land value as a basis to determine the economic impact.

In a local study, Cape Town's valuation roll was used as a basis to determine the economic impact of the rising sea level on coastal property. In a study conducted in the study area the researcher merely stated that the economic vulnerability of the area could be as much as 50% of the total budget of the district municipality and the five local municipalities along the specific coast. These studies indicate that there is a need to quantify the economic impact of the changing climate and specifically the changing sea level. However, none of these studies used market value to determine the economic impact of the rising sea level on coastal residential property.

It is essential to recognise that value as an economic concept is shaped in individuals' minds and is not intrinsic in a commodity. Valuers are therefore employed to interpret human behaviour in order to arrive at an opinion of value. In order to do this, they rely on market participants' past behaviour to determine the current value of a property. However, the slow onset of the changing climate and at this stage still predicted impact of the changing climate create a conundrum valuers will have to solve.

In order to understand the paradigm within which valuers operate, the valuation process was discussed with specific reference to market value, risk and uncertainty, SLRR and the ICM Act promulgated to adapt to and mitigate the anticipate rise in sea level. The risk and uncertainty introduced by the changing climate and specifically the rising sea level challenge the current paradigm property valuers operate in when they must develop an opinion of value of at-risk coastal real estate. The promulgation of the ICM Act has introduced more uncertainty. All of this highlights the need for a model, which property valuers can apply to analyse environmental risk.  The research methodology used in this study will be discussed in the next chapter.

# CHAPTER 4

# RESEARCH DESIGN

## 4.1 INTRODUCTION

In the previous chapter, the property valuer's paradigm was reviewed and concluded with the challenge presented by environmental risk and the promulgation of the ICM Act.

In this chapter the research design the researcher utilised to answer the research question is described. The philosophical paradigm from which the researcher approached the study is described, followed by the research paradigm or methodological choice, the research approach, research strategy, time horizon and techniques and procedures followed to collect and analyse data (Saunders, Lewis & Thornhill, 2016).

The focus of this study was to determine the extent to which the predicted rise in sea level and the subsequent promulgation of the ICM Act will affect the decisions made by property valuers in the coastal residential market of Sedgefield, South Africa. Property valuers are relied on to provide an objective and independent opinion of value to reduce risk and provide certainty when participants in a real estate market are interested in buying, selling, mortgaging, insuring or assessing property for rating purposes. Property valuers therefore provide expert advice in real estate matters by interpreting the behaviour of market participants according to valuation theory and applying the valuation process to determine the market value of immovable property as at the valuation date (IVSC, 2013).

## 4.2 PROBLEM STATEMENT

The rising sea level and the subsequent promulgation of the ICM Act create a risk, which will decrease the future benefits of coastal residential real estate in Sedgefield, South Africa. The problem is that property valuers do not have an acceptable mechanism to quantify this risk when they value coastal residential property.

Since no previous studies exploring property valuers' experience concerning climate change risk was found in the literature, the researcher decided to conduct a phenomenological study to determine property valuers' lived experience of rising sea level and to develop an instrument to assist property valuers in valuing coastal residential properties.

### 4.2.1 Aim of the study

The aim of the study was to investigate the predicted effect and ensuing risk of a rise in sea level on the valuation behaviour of property valuers in the coastal residential market and to design an instrument that can be used to estimate the market value of coastal residential real estate.

### 4.2.2 Central research question and subquestions

The central research question was: How does the predicted rise in sea level and its ensuing risk affect property valuers' behaviour in the coastal residential real estate market in Sedgefield, South Africa and how should property valuers quantify the climate change risk?

The subquestions derived from the main question were:

1. Are the property valuers practising in the coastal real estate market aware of climate change and the consequential risk of a rise in sea level on coastal residential real estate in Sedgefield, South Africa?
2. How do property valuers deal with the rising sea level when they develop an opinion of value in the coastal real estate market in Sedgefield, South Africa?
3. How do property valuers adapt to or mitigate the anticipated rise in sea level?
4. Are the knowledge, attitudes and behaviour of market participants a reflection of the current market behaviour in Sedgefield, South Africa?
5. How should property valuers:
    a. identify at-risk coastal residential real estate;
    b. ascertain the vulnerability level of at-risk real estate;

c. quantify the risk; and

d. include climate change risk when they develop an opinion of value for coastal residential real estate?

The aim was to design a model that will assist property valuers in quantifying the risk created by the rising sea level and that they can apply when they develop an opinion of value of an at-risk coastal residential property.

## 4.3 RESEARCH PROCESS

The research process as described by Saunders et al. (2016) was applied in this study. Saunders et al. (2016) explain that although the research process comprises a number of steps linked together, it is not necessarily a linear process. Creswell (2014) refers to the different stages of the research process. To clarify the role of research philosophy and theory development in the research process, Saunders et al. (2016:124) use the analogy of an onion called the '*research onion*'.

Figure 4.1 provides a graphic depiction of the research process that was followed to provide a scientific basis for the research undertaken.

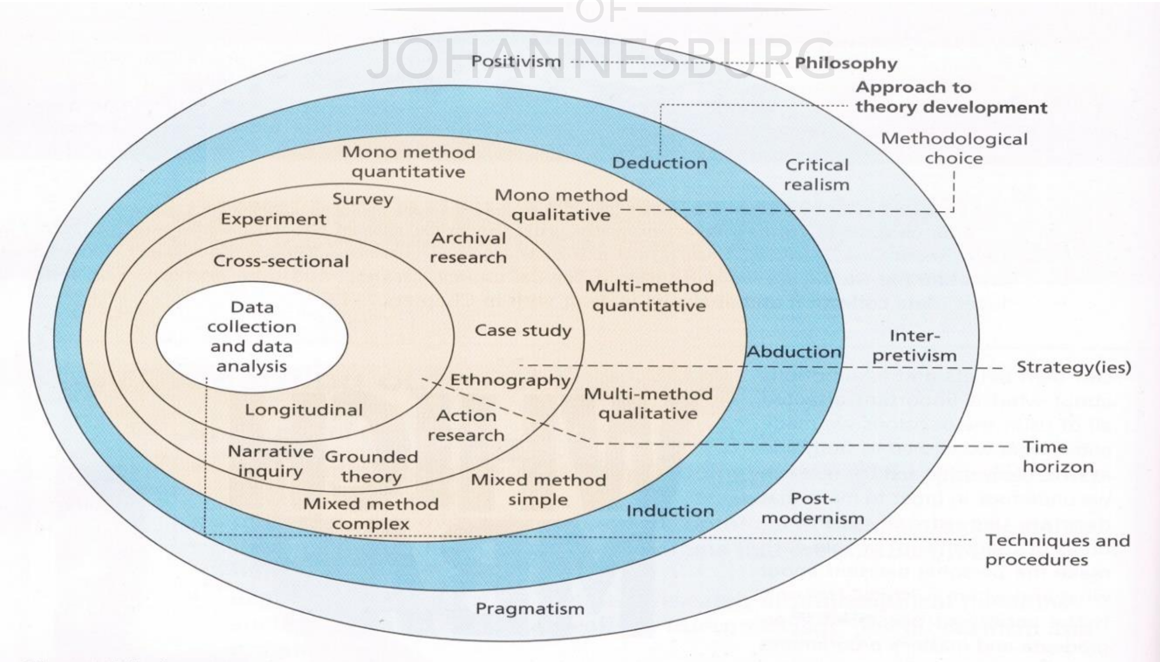


**Figure 4.1: Research onion**
***Source:*** *Saunders et al. (2016:124)*

According to Saunders et al. (2016), research or the way in which knowledge is developed is influenced by the lens through which a researcher views the world. The outer layer of the research onion represents and describes the different well-defined worldviews or philosophies underpinning researchers' development of knowledge.

The second layer represents the different approaches a researcher can apply to develop theory. In this study 'approach to theory development' and 'methodological choice' were changed around because there is a clear link between pragmatism as a research philosophy and mixed methods as a research method (Saunders et al., 2016:124). The third layer of the onion refers to the different research methodologies. The different research strategies the researcher can apply are in the fourth layer. The time horizon of a research project appears in the fifth layer and the model concludes with techniques and procedures for data collection and analysis in the centre. This model provides researchers with a well-defined and systematic approach to develop the research design in a research project.

## 4.4 RESEARCH PHILOSOPHY

Paradigm is defined as a *'set of basic and taken-for-granted assumptions which underwrite the frame of reference, mode of theorising and ways of working'* (Saunders et al., 2016:723). Creswell (2014) prefers to refer to a worldview rather than a paradigm. He describes a worldview as the '*general philosophical orientation about the world and the nature of research that a researcher brings to a study*' (Creswell, 2014:6). The researcher approached this study from the perspective of a property valuer in the coastal residential real estate market.

Property valuers are pragmatists who are real-world practice-oriented, problem-centred and attentive to the consequences of events or actions that influence a specific property market (Boyd, 2014; McCluskey & Borst, 2007). According to Creswell (2014:9), the pragmatic worldview focuses on finding answers to research problems by means of '*what works*' rather than complying with a preconceived objectivist or subjectivist ontological position. Pragmatism is more concerned with the research question and questions asked regarding the research than with the method used. Saunders et al. (2016:724) describe pragmatism as the:

> *philosophical stance that argues that concepts are only relevant where they support action. It considers research, starts with a problem, and aims to contribute practical solutions that inform future practice. Pragmatists' research may vary considerably in terms of how objectivist or subjectivist it is.*

The aim of pragmatism is to use the research method best suited for the examination of a specific phenomenon (Feilzer, 2010). Cameron (2011) suggests that pragmatism is a practical approach to a problem and it has an undeniable connection with the mixed methods research approach.

## 4.5 RESEARCH DESIGN

Saunders et al. (2016:726) define the research design as a framework for the *'collection and analysis of data to answer [the] research question and meet research objectives providing reasoned justification for [the] choice of data sources, collection methods and analysis techniques*'.

Mixed methods research is defined as the '*use of both quantitative and qualitative data collection techniques and analysis procedures either at the same time (concurrent) or one after the other (sequential)*' (Saunders et al., 2016:720). Creswell (2014:4) describes mixed methods research as '*an approach to inquiry that combines or associates both qualitative and quantitative forms'.* The use of both qualitative and quantitative data provides a better understanding of the influences within a real estate market (Bell & Bell, 2015). Bell and Bell (2015) assert that although real estate can be described in numbers, it is people who negotiate and conclude transactions. This confirms Ihuah and Eaton's view (2013) that mixed methods research was the most appropriate for the research they conducted on the sustainable management of public housing estates.

Hastjarjo (2015) maintains that the incorporation of both qualitative and quantitative data provides a comprehensive understanding of a particular real estate development problem instead of a particular positivist or interpretivist view of the data. Wong (2016) used mixed methods research to examine the robustness of long-term determinants on house prices in Melbourne.

A two-stage mixed methods study was therefore deemed appropriate to investigate the behaviour of property valuers regarding the predicted rise in sea level in Sedgefield.

Johnson, Onwuegbuzie and Turner (2007) indicate that a mixed methods approach which makes use of both the qualitative and quantitative approaches adds to the breadth and depth of understanding of a research problem. Creswell and Plano Clark (2011) believe that the acceptance of a mixed methods design is situated in the harmonious use of both a qualitative and a quantitative approach to secure a better understanding of a research problem, which cannot satisfactorily be resolved by the qualitative or quantitative approach alone.

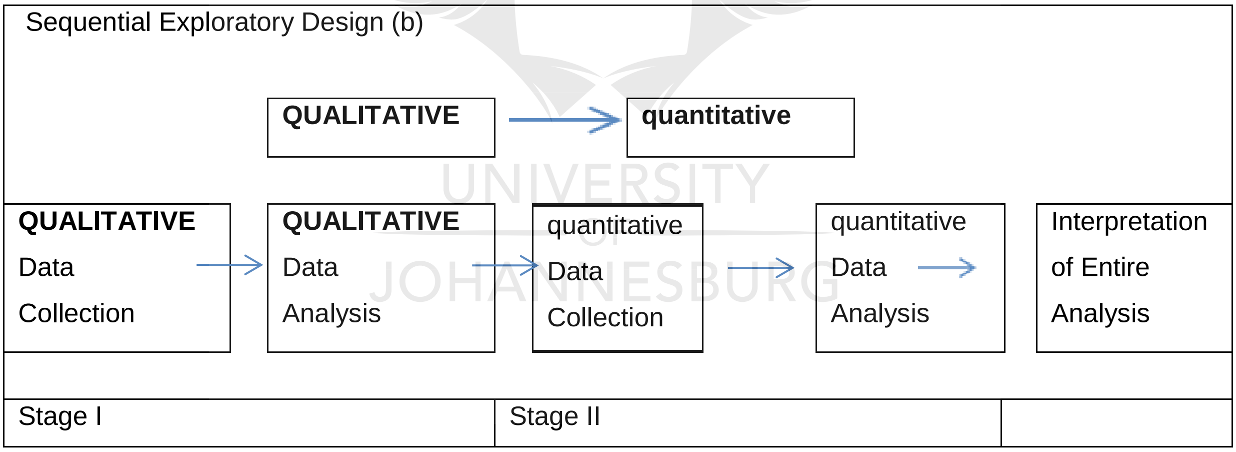


**Figure 4.2: Sequential exploratory design used in study**

***Source:*** *Adapted from Creswell (2009)*

A sequential exploratory strategy, commencing with qualitative data collection and analysis, was applied. This was followed by a stage of quantitative data collection and analysis (Creswell & Plano Clark, 2011.

Jupp (2006:110) defines exploratory research as "*a methodological approach that is primarily concerned with discovery and with generating or building theory*". According to Saunders et al. (2016), exploratory studies are conducted when a researcher wants to shed light on his or her insight into a phenomenon.

Because of the absence of specific valuation guidelines to account for the rising sea level and the slow onset of climate change, an exploratory sequential design was regarded as the best-suited research design for this study. The purpose of the exploratory sequential design in this study was to develop an in-depth understanding of climate change as a phenomenon with specific reference to the rising sea level to develop an instrument that can be used by property valuers when they assess the market value of coastal residential property.

The study commenced with an exploration of property valuers' knowledge, attitudes and behaviour regarding the rising sea level in the first stage, a qualitative inquiry. Primary data was collected by means of personal interviews with property valuers in the sample area. This was followed by the second stage in which secondary data, sales data from the sample area, was statistically analysed and compared with the results from the first stage. The first stage carried greater weight than the second stage, which was used as a control to confirm or deny the findings in stage 1. According to Creswell and Plano Clark (2007), the research question, research objectives or a specific research procedure, among other things, can influence the weight allocated to either the qualitative or the quantitative method.



Creswell (2009) suggests that the aspects of timing, weighting, mixing and theorising should be considered before choosing a strategy. Timing means to decide on the sequence in which the approaches (qualitative or quantitative) will be applied or whether they will be applied concurrently (Creswell, 2014). In this study, a sequential approach was followed, starting with the qualitative approach and followed by the quantitative approach.

Weighting is an indication of the order of importance as the approach with the highest weighting will normally indicate the emphasis of the study (Creswell, 2014). As seen by the research question, this study was concerned with the behaviour of property valuers and therefore the qualitative stage (80%) carried more weight than the quantitative stage (20%).

Mixing of data may occur during data collection, analysis or interpretation, or in all three (Creswell, 2014). The data was collected, analysed and interpreted separately, after which the results were compared.

Theorising is whether the research design is driven by a theory. In this study the research design was influenced by property valuation theory (Creswell, 2014). The decision to use a sequential exploratory design was influenced by property valuation theory. Property valuers interpret human behaviour when they develop an opinion of value (Ratcliff, 1979). To develop this opinion of value, they rely on different sources, mostly qualitative in nature, as well as on property sales data, i.e. quantitative data, when they use the sales comparison approach. According to Ayittey, Gyamfi-Yeboah and Gambrah (2006), property valuers depend mostly on quality scripted data rather than numeral data when they develop an opinion of value.

Mixing of data is typical for property valuers as they are constantly collecting both qualitative and quantitative data. The mixed methods design allowed the researcher to triangulate the data to determine if the findings in the qualitative inquiry (stage 1) were confirmed or refuted by the results of the quantitative inquiry (stage 2) (Saunders et al., 2016). The research question and objectives applied in the mixed methods design were shaped by valuation theory and the process was described in chapter 3.



## 4.6 RESEARCH APPROACH

Creswell (2014) refers to three research approaches, namely qualitative, quantitative and mixed methods. Saunders et al. (2016) refer to inductive, deductive and abductive research approaches.

Creswell (2014) explains that qualitative research examines how individuals or groups understand individual or communal problems, whereas quantitative research tests the relationship between variables in objective theories with mixed methods located in between the qualitative and quantitative approaches. Mixed methods combine the qualitative and quantitative approaches to achieve an unimpaired insight into a research problem (Creswell, 2014).

Saunders et al. (2016) state that an inductive approach is used when the researcher investigates a phenomenon in an attempt to develop a theoretical position. A deductive approach is used when the research question is theory driven and the researcher attempts to verify or falsify a theoretical position. The abductive approach is used when data regarding a phenomenon is collected in order to develop a new theory or change an existing theory and to test the theory against additional data (Saunders et al., 2016).

In this study the terms ‘qualitative’ and ‘quantitative’ as per Creswell (2014) are used and not ‘inductive’ and ‘deductive’ as used by Saunders et al. (2016). This decision was based on the terminology used in the explanation of the sequential exploratory design in Figure 4.1. A sequential exploratory design starts with an initial stage of qualitative data collection and analysis, followed by a second stage of quantitative data collection and analysis (Creswell & Plano Clark, 2011). The decision regarding the research approach followed in this study was further guided by the research problem, lack of knowledge concerning the problem and the availability of data (Ellis & Levy, 2009). Bell and Bell (2015:310) argue that using both qualitative and quantitative data, i.e. mixed methods, will provide property valuers with a better understanding of the issues and motivations in a specific real estate market.



The reasons for the use of the different approaches are summarised in Table 4.1 below.

**Table 4.1: Deduction, induction and abduction: from reason to research**

| | **Deduction** | **Induction** | **Abduction** |
|---|---|---|---|
| **Logic** | In a deductive inference, when premises are true, the conclusion must also be true | In an inductive inference, known premises are used to generate untested conclusions | In an abductive inference, known premises are used to generate testable conclusions |
| **Generalisability** | Generalising from the general to the specific | Generalising from the specific to the general | Generalising from the interactions between the specific and the general |

| | | | |
|---|---|---|---|
| **Use of data** | Data collection is used to evaluate propositions or hypotheses related to an existing theory | Data collection is used to explore a phenomenon, identify themes and patterns and create a conceptual framework | Data collection is used to explore a phenomenon, identify themes and patterns, locate these in a conceptual framework and test this through subsequent data collection and so forth |
| **Theory** | Theory falsification or verification | Theory generation and building | Theory generation or modification; incorporating existing theory where appropriate, to build new theory or modify existing theory |

***Source:*** *Saunders et al. (2016:145)*



Empirical studies relying on quantitative data only are as accurate as the data they depend on and fail to notice the basis of the data (Bell & Bell, 2015). This supported the researcher's decision to use a sequential exploratory design with two distinct stages in search of an answer to the research question. The researcher did not mix the approaches to inquiry, but retained the layout as proposed in the sequential exploratory design (Creswell, 2014).

The first stage was a qualitative inquiry exploring valuers' knowledge, attitudes and behaviour relating to the climate change phenomenon. The second stage was an objective quantitative inquiry using secondary data to verify if the knowledge, attitudes and behaviour of property valuers are a reflection of current market behaviour in the study area.

## 4.7 RESEARCH STRATEGY

The mixed methods research (sequential exploratory) design requires both qualitative and quantitative inquiry as described in 4.6 above. A phenomenological research strategy was followed to find an answer to the research question in stage 1. A case study research strategy was followed to find an answer to the research question in stage 2.

### 4.7.1 Phenomenological research

Creswell (2014:13) defines phenomenological research as '*a strategy of inquiry in which the researcher identifies the essence of human experiences about a phenomenon as described by participants*'. According to Reiners (2012:1), phenomenology stems from the inductive qualitative research tradition founded by Husserl. The aim of phenomenological research is to describe the lived experience of the participants in a study (Maypole & Davies, 2001; Robinson & Reed, 1998; Greene, 1997). For Clancy (2013), the objective of phenomenology is to reach an understanding of an individual's beliefs, opinions and misgivings regarding a specific phenomenon. Lester (1999) explains that phenomenology investigates events from an individual's point of view. Wilson (2011) submits that even though phenomenological research is not often used in financial research, it can provide a better understanding of financial managers' lived experience.

Lester (1999) maintains that phenomenology provides an understanding of an individual's or group's activities and conduct and cuts through the disarray of presumptions and conventional understanding. Giorgi (2009) and Moustakas (1994) state that researchers normally use interviews to gather data regarding the lived experience of participants in a study. Hollinger (2016:83) elected to conduct phenomenological research as it allowed her to *'identify viewpoints, moral development dilemmas, and descriptions that are incorporated in the essence of dual agency transactions*'.

The aim of this study was to investigate property valuers' lived experience: their knowledge, attitudes and behaviour regarding the climate change phenomenon on property valuation practice in South Africa at a specific time. The lived experience of property valuers was explored by means of qualitative inquiry in stage 1 and quantitative inquiry in stage 2.

The qualitative inquiry explored valuers' understanding of the impact of the rising sea level by means of a phenomenological study. The broad phenomenon studied was the changing climate. The study focused on property valuers' knowledge and attitude concerning the risk inherent in the rising sea level and the effect of the ICM Act.

Creswell (2014) warns against the possibility that the researcher may influence participants' views with his or her own. To prevent any influence from the researcher, structured interviews were used to ensure that the interviews were conducted on an equal basis. Saunders et al. (2016:728) define structured interviews as a data collection technique *'in which an interviewer physically meets the respondent, reads them the same set of questions in a predetermined order, and records his or her responses to each*'.

Data was collected during 1-hour long interviews which the researcher conducted with the participants. The interviews were recorded and transcribed and the data analysed by the researcher. This will be discussed in detail in chapter 5.

### 4.7.2 Case study research

Saunders et al. (2016:711) define case study research as '*the empirical investigation of a particular contemporary phenomenon within its real-life context, using multiple sources of evidence'.* Yin (2014) describes case study research as '*a study that investigates a contemporary phenomenon in depth and in its real-world context'.*

The second stage of this research was an objective quantitative inquiry to establish if the knowledge, attitudes and behaviour of property valuers reflect current market behaviour in Sedgefield. The reasons why Sedgefield was identified as the basis for the case study will be discussed in depth in 4.8.4. The aim of the case study research was to establish if there was agreement between what happens in the Sedgefield residential real estate market and what the property valuers reported during the interviews.

Yin (2014) identifies five components of case study research: the question motivating the research, any propositions, the unit of analysis, the rationale which links the data and the propositions and the criteria used to interpret the findings. The question that motivated the quantitative inquiry in this mixed methods study was: *Are the knowledge, attitudes and behaviour of property valuers a reflection of the current market behaviour in Sedgefield*?

The proposition which gave direction to the quantitative inquiry was the current market behaviour in Sedgefield's real estate market. Valuers interpret human behaviour by analysing selling prices (Ratcliff, 1979). The price for which properties within a specific real estate market is sold is an indication of how market participants (buyers and sellers) behave in a specific market.

The third component of a case study (Yin, 2014) is the unit of analysis or the "case". In this study two areas within Sedgefield were chosen, the reasons for which will be discussed in depth in 4.8.2. However, the sales data for both these areas was analysed to determine trends over the last 20 years.



The last two of the components (Yin, 2014), i.e. the rationale which links the data, and the propositions and the criteria used to interpret the findings will be discussed under 4.8.4.

## 4.8 DATA COLLECTION AND ANALYSIS

### 4.8.1 Population

The population was all professional associated property valuers (without restrictions) and professional property valuers registered with the SACPVP. At the time of writing, there were approximately 800 property valuers who could perform property valuations without any restrictions in South Africa (Seota, 2016). These property valuers were allowed to perform valuations of all immovable property within the borders of South Africa. This includes residential properties along the entire South African coastline of 3 200 km.

### 4.8.2 Research site for both stages 1 and 2 of the study

According to Creswell (2009), the researcher should *purposefully select* a site to carry out the study. He emphasises that the idea behind qualitative research is to *'purposefully select participants or site (or documents or visual material) that will best help the researcher understand the problem and the research question"* (Creswell, 2009:178).

The research site for stage 1 was the area known as the southern Cape coast in South Africa, specifically Sedgefield. The researcher's decision was informed by the research conducted by Hughes in 1992 and Umvoto Africa (2010b) for the Eden District Municipality and the SARVA (South Africa, 2010).

According to the SARVA (South Africa, 2010), an increase in water temperature will lead to increased sea levels. It also predicts that the changing climate may create storms of greater intensity that will affect coastal settlements. Although this will affect all the coastal residential properties along the South African coastline, Hughes (1992) identified four particular areas, namely Greater Cape Town (Melkbosstrand to Gordon's Bay), South Cape coast (Mossel Bay to Nature's Valley – Sedgefield is more or less halfway between Mossel Bay and Nature's Valley), Port Elizabeth and the KZN South coast and Greater Durban (Southbroom to Ballitoville). In a study commissioned by the Western Cape provincial government regarding the climate change risk in the Eden District Municipality, Umvoto Africa (2010b) confirmed Sedgefield as one of the most vulnerable sites.

This study focused on coastal residential properties in Sedgefield and specifically two suburbs. The first suburb, known as Sedgefield Island is generally lower than 5 m amsl. The second suburb, Sedgehill, is higher than 20 m amsl. The purpose of the study was to determine the impact of rising sea levels on coastal residential property and the implications for valuers. Sedgefield was used as the only research site due to its vulnerability and it is accepted that the results therefore cannot be generalised. However, valuers should be able to use the results from the study to assist them when they conduct valuations in other coastal residential areas along the South African coastline.

### 4.8.3 Participant selection for qualitative inquiry (stage 1)

Purposive sampling was used to select the participants. Tashakkori and Teddlie (2003) maintain that purposive sampling is selecting with a *specific purpose* in mind and not at random. "*Purposefully [selecting] participants or sites (or documents or visual material) means that qualitative researchers select individuals who will best help them understand the research problem and the research questions*" (Creswell, 2009:231). Although it is generally anticipated that sites or individuals will be selected for a purpose, Patton (2002) believes that there are no guidelines to guide purposeful sampling in mixed methods research. However, Teddlie and Yu (2007) have compiled guidelines based on those presented by other authors, for example: Curtis, Gesler, Smith and Washburn (2000), Kemper, Stringfield and Teddlie (2003 and Miles and Huberman (1994).

Creswell (2014) suggests that the participants in a phenomenological study may be located at a single site or not. He emphasises that phenomenologists' aim is to portray the similarities participants' experience. It is important to note that the phenomenon studied, i.e. the rising sea level, is in the process of materialising and it is its slow onset and the adaptation measures introduced by the South African government that were the foundation of the research question. Although none of the participants had experienced the phenomenon, it is its future consequence that must be considered now. In this study the participants were professional valuers and professional associated valuers brought together by the fact that they were registered with the SACPVP and in close proximity to the research site, namely Sedgefield. The participants in the qualitative stage of the research were selected according to the following sampling strategy:

1. A list of all the property valuers on South Cape coast (Mossel Bay to Nature's Valley) registered with the SACPVP was acquired from the SACPVP's webpage. The list included candidate valuers, professional associated valuers with and without restrictions as well as professional valuers, 53 in total.
2. The list was organised according to magisterial district, namely Mossel Bay (12), George (29) and Knysna (12). The magisterial district of Knysna includes Sedgefield, Plettenberg Bay and Nature's Valley.
3. The candidate valuers were removed from the list as they are not allowed to receive instructions and cannot sign off valuation reports. They totalled 3 in Mossel Bay, 7 in George and 3 in Knysna.
4. The remaining names, i.e. 40 professional associated valuers and professional valuers, were arranged according to the magisterial district in which they were registered: Mossel Bay: 2 professional valuers and 7 professional associated valuers, George: 9 professional valuers and 13 professional associated valuers and Knysna: 5 professional valuers and 4 professional associated valuers. Any one of these valuers is allowed to conduct valuations of coastal residential properties.
5. A purposive sample was drawn by inviting all registered professional valuers and professional associated valuers to participate in the research. The invitation was in the form of an e-mail in which the purpose of the research was explained and a request to arrange an interview.
6. Of the 40 valuers invited, 14 valuers agreed to be interviewed. One cancelled shortly before the interview due to a family emergency. Of the 13 interviews, one was not transcribed due to the inappropriate language used by the interviewee.
7. The 13 interviews represent 33% of the total of 40. See a breakdown of all the responses in Table 4.2.

**Table 4.2: Responses to invitation to participate**

| | Number | Reason |
|---|---|---|
| 14 | 35% | Invited |
| 13 | 32.5% | Interviewed |
| 12 | 30% | Transcribed and analysed |
| 26 | 65% | Did not participate |
| 5 | 12.5% | E-mail came back as undeliverable after three attempts and no response to telephone calls |
| 1 | 2.5% | Declined the invitation declaring unwillingness to participate |
| 4 | 10% | Declined the invitation because they were not involved in valuation of residential properties |
| 14 | 35% | Indicated that they were retired or pursuing other business interests |
| 2 | 5% | Not available due to being on annual leave |



The sample size in qualitative research is normally not predetermined. When data saturation is achieved, that is when no new concepts are identified during additional interviews, the number of participants are accepted as sufficient (Sargeant, 2012). Palinkas, Horwitz, Green, Wisdom, Duan and Hoagwood (2013) claim that in phenomenological studies 3-6 participants are sufficient if they are interviewed multiple times. Creswell (2014), citing Polkinghorne (1989), believes that between 5 and 25 interviews are sufficient but they do not refer to multiple interviews. In two real estate related phenomenological research PhD studies, Kakulu (2008) conducted 13 interviews with participants he purposively selected from a population of 500 property valuers in Nigeria. Hollinger (2016) purposively selected 20 participants from an undisclosed population in North Central Mississippi and successfully conducted interviews with 14 participants. 13 participants representing 33% of the possible participants is midway between the numbers Creswell believes are sufficient.

The interviews were arranged for between 3 and 11 January 2013. The appointments were scheduled for an hour and the process was as follows:

1. In the introduction and to establish rapport, the interviewer assured the interviewees that they would remain anonymous and again asked if they were willing to participate. He also informed them that they could end the interview at any time. The interviewee's permission was asked to record the interview. All the interviews were recorded on a digital voice recorder as well as on an iPad, with the application called Dragon Recorder.
2. A brief explanation of the objective was provided, the interviewee was handed a copy of the questionnaire and the interviewer had a copy on which notes were made during the interview.
3. At the end of the interview the interviewer thanked the respondent for their participation and again asked if their response could be used in the study.
4. The questionnaires were marked interviewee 1 to 13, and the date of the interview as well as the time the interview started and ended were recorded.
5. Only three of the interviewees were English-speaking and all the others were Afrikaans-speaking and preferred to respond to the questions in Afrikaans.
6. The interviews were transcribed by two professional transcription companies, one did the English interviews and another the Afrikaans interviews.
7. In January 2015 the transcriptions of the interviews as well as a copy of the questionnaire were e-mailed to each interviewee with the request to confirm the content and to make any changes they felt necessary. The time delay was on purpose with the intention to establish if there was a change in their knowledge, attitude or behaviour. This was repeated in January 2017, providing the researcher with an opportunity to establish if the participants had changed their opinions over time.

### 4.8.4 Sample selection for quantitative inquiry (stage 2)

The population was all coastal residential properties along the southern Cape coast from Mossel Bay to Nature's Valley. Hughes (1992) as well as Umvoto Africa (2010a) identified this area as vulnerable to the changing climate and specifically to a rising sea level.

A purposive sample was drawn, namely Sedgefield Island, a suburb in Sedgefield, for the following reasons:

- It was the area of interest that prompted the researcher's inquiry into the influence of climate change on the market value of coastal residential properties.
- Sedgefield is more or less halfway between Mossel Bay and Nature's Valley (see Figure 4.3).
- Both Hughes and Umvoto Africa identified Sedgefield as vulnerable to the rising sea level.
- Sedgefield has experienced three major floods in the past 20 years with regular small-scale flooding, the latest being 1 September 2015 (Kirsten, 2015).

* In all three major floods Sedgefield Island was affected.

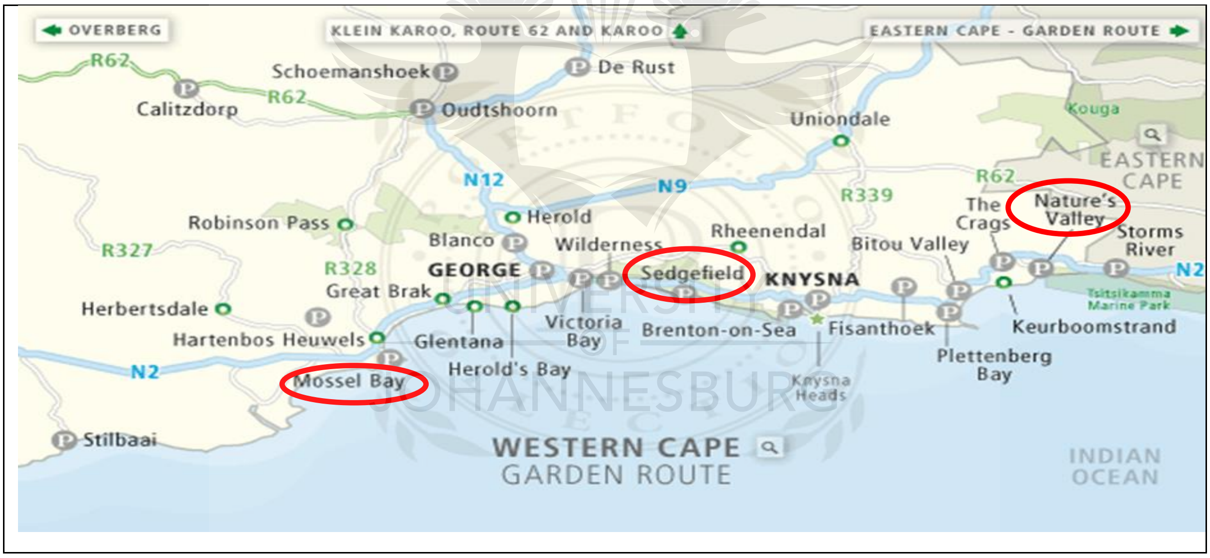


**Figure 4.3: Map showing population, Mossel Bay to Nature's Valley with Sedgefield in centre**

***Source:*** *http://www.portfoliocollection.com/maps/wc-garden-route.gif*

### 4.8.5 Qualitative data collection: Stage 1

#### *4.8.5.1 Structured interviews*

The researcher began with a qualitative approach to extract knowledge and perceptions from property valuers who valued coastal residential property, to discover if they were aware of the predicted rise in sea level and how they perceived this to affect the market value of coastal residential properties.

Since the researcher did not reside in and was not close to the research site, had limited time to collect the primary data and only 13 participants agreed to be interviewed, it was decided to conduct in-depth personal interviews with the willing participants. It was further decided to use structured interviews consisting of open-ended and closed questions to guide the interviews. According to Miles and Huberman (1994), open-ended questions in structured interviews allow themes to emerge from the interview narratives. A copy of the interview schedule is attached as Annexure 1.

The purpose of the interview schedule was to gather data from valuers who conducted valuations of coastal residential property regarding their knowledge, attitudes and behaviour of the changing climate. The research objectives were used as a guide to design the interview schedule. The questions in the interview schedule were formulated around themes to obtain information from valuers regarding their demographics, the changing climate, valuation practice and the valuer’s attitude towards the changing climate.

#### *4.8.5.2 Reliability and validity*

According to Creswell (2009), interviews are advantageous when participants cannot be observed directly, participants can provide historical information and the researcher can control the line of questioning. However, it is limited in that the information is filtered through the views of the interviewees and is thus indirect information. The information was collected in a place designated by the interviewee and not a neutral setting. Responses might also have been biased by the researcher’s presence as the interviewees were not all evenly coherent and perceptive and at times, the researcher had to explain the meaning of some of the questions.

Structured interviews assist the interviewer to remain neutral, allow for a direct comparability of responses and eliminate inconsistency in questions in an attempt to ensure reliability and validity (Cooper & Schindler, 2008). Creswell (2009) emphasises that validity in qualitative research is not the same as validity in quantitative research. He also claims that validity is not the *companion* of reliability or generalisability. According to Gibbs (2007), validity in qualitative research refers to the procedures a researcher uses to check the accuracy of his/her findings, and reliability in qualitative research is an indication that a researcher's application of a specific approach is consistent with other researchers' application of the specific approach. Gibbs (2007) suggests that to ensure reliability, the accuracy of transcriptions and the definition of codes should be confirmed, the researcher should also guard against a shift in meaning during coding, the communication among coders in team research should be synchronised and the codes developed by different researchers verified.

Except for the transcribers, the researcher was the only one who worked with the data. To ensure reliability of the transcriptions, they were sent to all the participants and they were asked to confirm if they agreed or disagreed with the content. The data should therefore be reliable as the researcher was the only person who developed and applied the codes.

Creswell (2009) suggests that the researcher should use more than one of the validity strategies mentioned below to check the accuracy of his/her findings. Any of the following eight strategies can be used: triangulation, having members check their responses, using rich and thick descriptions, stating the researcher's bias upfront, presenting all negative or discrepant information, spending extended periods in the field, using peer debriefing and appointing an external auditor.

The following validation strategies were employed in an attempt to ensure the validity of the data: *Triangulation* was applied in the study by way of the research design. The second stage in the mixed methods approach acts as a control to check if the behaviour of the market participants (buyers and sellers) in the Sedgefield real estate market were in agreement with the findings in the first stage, namely that of the valuers who interpret the behaviour of buyers and sellers to develop an opinion of value. *Member checking* was used to check the accuracy of the transcribed interviews. The transcription of each participant's interview together with a copy of the questionnaire was sent to them to confirm the content and accuracy of the transcription. They were also asked to change anything they did not agree with. Although not all the participants provided a *rich and thick description, some did*. However, the *researcher did declare his bias* right at the beginning of the study as well as at the start of each interview. Any *negative or discrepant* information received was declared as such. The last three strategies do not apply as the researcher did not *spend a prolonged time in the field*, and did not use *peer debriefing* or an *external audito*r in the study. From the aforementioned explanation, it is clear that the researcher did attempt to ensure that the data is valid.

Although qualitative research is conducted at a particular site or among particular individuals and the intention is not to generalise the findings to a broader audience (Creswell, 2009), the researcher believes the results may apply to other areas similar to the study area.

#### *4.8.5.3 Data analysis*



In qualitative research data, analysis is a continuing, developing, repetitive and non-linear process. Atlas.ti provides software support in the form of data analysis by assisting researchers with the coding and annotating activities (Henning et al., 2004). Although the intention was to use Atlas.ti to analyse the interviews, the researcher found it easier to analyse them manually due to the small number of interviews.

### 4.8.6 Quantitative data collection: Stage 2

The second, quantitative stage followed on the qualitative stage for determining if the valuers' views were reflected in market practices, namely the behaviour of purchasers and sellers.

Secondary data in the form of sales data for Sedgefield was used. Sales data for 20 years (1995 – 2015) was sourced from the South African Property Transfer Guide (SAPTG) through the University of Johannesburg library. The SAPTG is a database that acquires data directly from the deeds office and provides it to individual users in a user-friendly format. The data from the deeds office is very reliable as all property transactions in South Africa are recorded in the deeds office only after a thorough verification process (South Africa, 1937). The purpose of the use of sales data was to establish if property valuers' behaviour regarding the changing climate echoed the behaviour of purchasers and sellers in Sedgefield's property market. A secondary purpose was to establish if there were any noticeable trends that might indicate changes in the property market that can be linked to changing climate events.

#### *4.8.6.1 Data collection*

The Sedgefield valuation roll and the municipal map of Sedgefield Island were used to identify the erf numbers of all the residential properties in the suburb known as Sedgefield Island (see Figures 4.3 and 4.4). There were 565 residential erven in Sedgefield Island or 10% of the erven in Sedgefield. All the properties which were sold twice and more, 70 of the 565 properties, were identified and listed on a spreadsheet in order to establish trends. The height above sea level as well as the municipal valuation were included on the spreadsheet.



#### *4.8.6.2 Data analysis*

The data was statistically analysed to establish trends in selling prices and to determine if there was a relationship between prices and rising sea levels or flooding events. This was done by searching for decreases, increases or any irregularities in selling prices shortly after events that could be linked to a rise in mean sea level or a flooding event. All properties sold more than once over the past 20 years were identified to verify if movements in the property market could be linked to specific events, for example the floods in 2003, 2006 and 2007.

## 4.9 ASSUMPTIONS, DELIMITATIONS AND LIMITATIONS

### 4.9.1 Assumptions

The research was conducted from the researcher's point of view as a property valuer and social scientist with the assumption that the mainstream view of climate change is correct. As a valuer, the researcher cannot dispute climate scientists' findings regarding the changing climate and rising sea level and can therefore only report their findings.

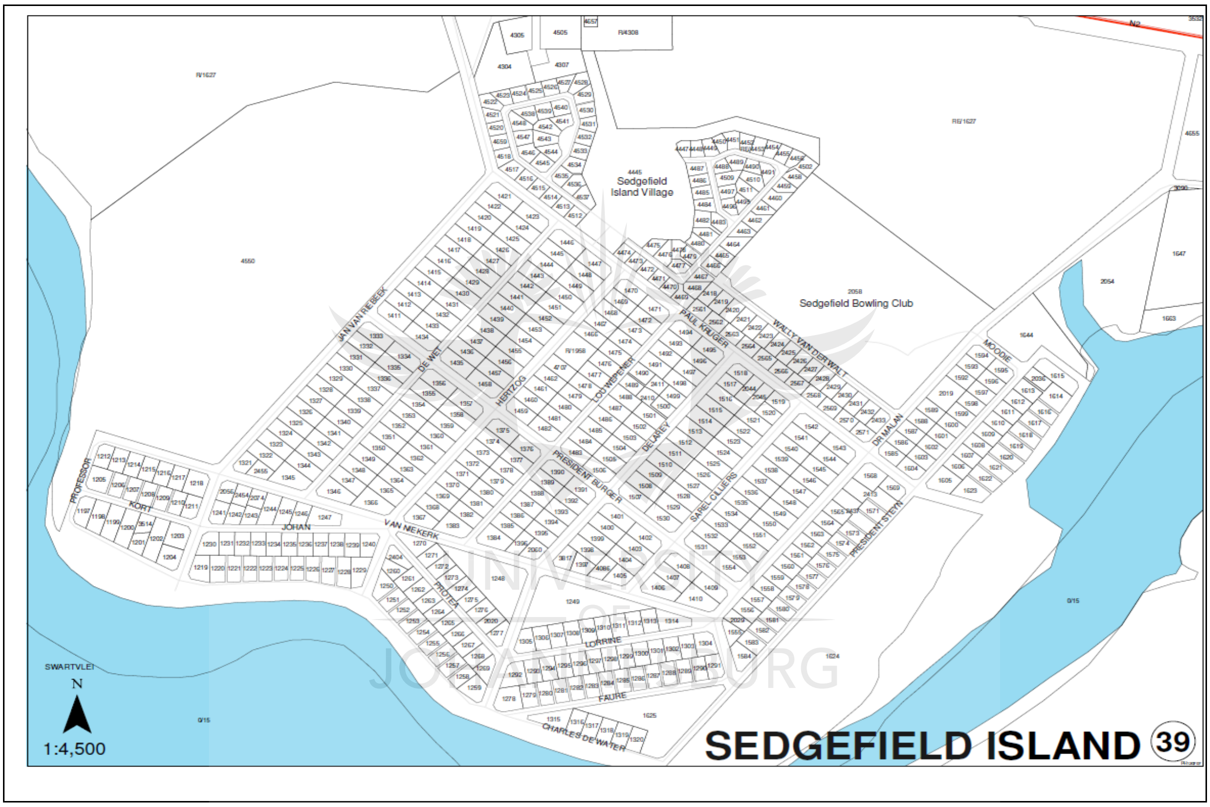


**Figure 4.4: Sedgefield Island municipal map**

***Source:*** *Knysna Municipality (2007)*

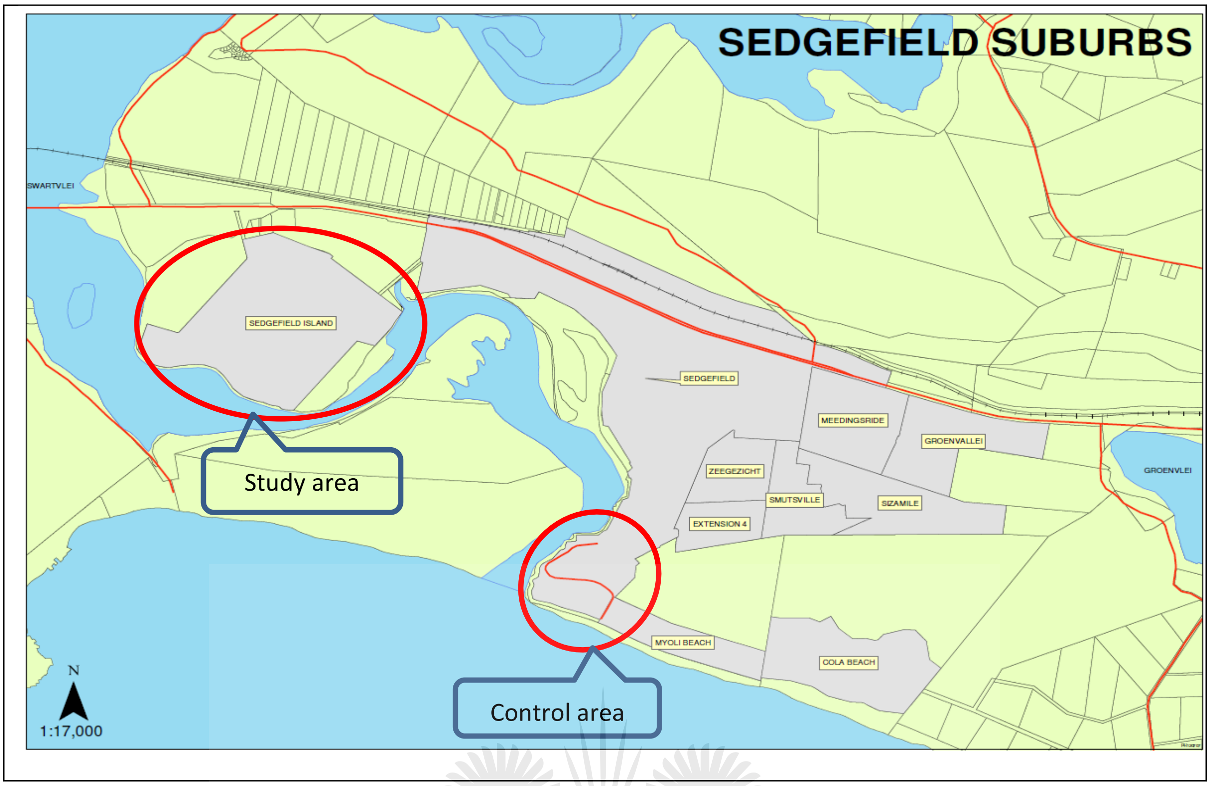


**Figure 4.5: Sedgefield suburbs**

***Source:*** *Knysna Municipality (2007)*

### 4.9.2 Delimitations

The research was further limited to only one of the effects of climate change, namely the rise in sea level and its effect on coastal residential properties.



Although the target population for the study was all immovable residential properties on the South African coast which may be damaged during a storm event, the specific focus of the research was on one of the four particularly at-risk areas in South Africa, namely the South Cape coast (Mossel Bay to Nature’s Valley) and to be precise Sedgefield (control area) and Sedgefield Island.

The research reflects the views of residential property valuers only. The decision to use only valuers was taken because a valuer’s opinion of value is a reflection of the behaviour of market participants in a specific property market. Market participants are the collective name for a group of individuals and institutions that are all involved in a specific property market, including buyers, sellers, estate agents, banks, insurers and local, provincial and central government. The decision to use only valuers was influenced by the researcher's inability to firstly identify and secondly to contact all the market participants (purchasers and sellers) over the past 20 years. The majority of the properties identified in the sales data are holiday homes occupied only during the summer holidays. The municipality was also not willing to provide the contact details of the owners due to the restrictions in the Protection of Personal Information Act, 2013.

### 4.9.3 Limitations

Because of this precise demarcation of the research site and using only valuers as participants, it is acknowledged that the results are limited and cannot be generalised. Although it was never the intention to generalise as market conditions and behaviour of market participants differ between property markets, the results of the study might guide valuers in other similar areas along the South African coastline.

## 4.10 ETHICAL CONSIDERATIONS

The proposal for study was approved by the Faculty of Economic and Financial Sciences, Higher Degrees Committee, which *"implies that the research will be undertaken in compliance with all applicable statutory and ethical guidelines, as defined in the faculty-specific regulations of the faculty calendar or academic information brochures and the policy document for academic ethics*" (University of Johannesburg, 2013:21).

An open invitation to participate in the study was e-mailed to the 40 potential participants. Only the participants who indicated their willingness to participate were approached to arrange interviews. The participants were fully informed that their right to anonymity, confidentiality and privacy was appropriately protected and that they could withdraw at any stage without any negative consequences.

Interviews were conducted on a one-on-one basis and voice recorded only after the participant agreed to be recorded. The recordings will be kept in a safe place for a period prescribed by the University of Johannesburg.

The transcribed interviews were sent to the interviewees to confirm the content and for their approval.

## 4.11 SUMMARY

The aim of the research was to investigate the predicted effect and consequential risk of a rise in sea level on the behaviour of property valuers. The coastal residential market of Sedgefield was chosen due to its vulnerability to the rising sea level. The research was conducted from a property valuer's point of view to develop guidelines to assist property valuers when they estimate the market value of coastal residential properties. Valuers are pragmatists who are real-world practice oriented, problem-centred and attentive to the consequences of events or actions that can influence a specific property market.

The central question that guided the research was how the predicted rise in sea level and consequential risk affected the behaviour of property valuers in the coastal residential market of Sedgefield and how they should quantify the climate change risk.

A two-stage mixed methods approach with a sequential exploratory design was followed with the aim of finding an answer to the research question. The first stage was a qualitative inquiry by way of a phenomenological study exploring property valuers' understanding of the impact of the rising sea level. The second stage was an objective quantitative inquiry following a case study approach to establish if purchasers and sellers' behaviour in the Sedgefield property market were in agreement with property valuers' understanding of the problem.

In stage 1, 13 property valuers were interviewed. The 13 represent 32.5% of the property valuers registered with the SACPVP on the southern Cape coast. The interviews were transcribed and coded and the codes themed. In the second stage the sales data for two areas in Sedgefield, namely Sedgefield Island (study area) and the area known as Sedgehill (control area), was collected and analysed to establish if the property valuers' views expressed during the interviews were a reflection of the property market in Sedgefield.

The study was based on the assumptions that climate change is a reality and the climate scientists' findings are correct. The study was also conducted from a property valuer's point of view and since the larger part of the study is qualitative, the results cannot be generalised. The results and findings of qualitative data will be reported and discussed in the next chapter.

# CHAPTER 5

# REVIEW OF PROPERTY VALUERS' KNOWLEDGE, BEHAVIOUR AND ATTITUDES ON THE CHANGING CLIMATE

## 5.1 INTRODUCTION

In the previous chapter, the research design and methodology applied to acquire a better understanding of how property valuers respond to the predicted rise in sea level and the consequential risk were described.

In this chapter the knowledge, behaviour and attitude of property valuers will be examined. Data was collected through one-on-one semi-structured interviews with professional property valuers practising in a coastal residential real estate environment.

An interview guide directed the semi-structured interviews. The interviews were divided into four sections:

- Section A: Closed questions regarding demographics. The questions were general in nature to determine who the participants were and if they fit the profile of a typical property valuer.
- Section B: The changing climate. The knowledge of and attitudes of property valuers practising in Sedgefield's property market towards the consequential risk of a rise in sea level were determined.
- Section C: Valuation practice and changing climate. These questions determined if and how property valuers used their knowledge of the rising sea level when they explored the property market in Sedgefield.
- Section D: Property valuers' attitude towards the changing climate. This section investigated the behaviour of property valuers in adapting to and mitigating the anticipated rise in sea level.

## 5.2 DATA ANALYSIS PROCEDURE

The semi-structured interviews were conducted on a one-on-one basis in the participants' office except for two who preferred to meet in a local coffee shop. Expert transcribing services transcribed the interviews. The researcher compared the notes made during the interview to reaffirm the context and content of the interviews.

A first cycle of coding was conducted of the responses to the open-ended questions using holistic coding within an exploratory coding methodology (Saldaña, 2012). The purpose was to obtain a basic idea of concerns and arguments raised by the participants (see Annexure 5.1). A second cycle of coding was conducted using descriptive coding. According to Saldaña (2012), descriptive coding summarises the topic contained in a passage in a short phrase or a word (see Annexure 5.2). Saldaña emphasises that the codes used are not abbreviations of the content but identify the topics. The coding was concluded by applying pattern coding as a third level of coding to identify emerging themes (Saldaña, 2012); see the coding framework in Table 5.1.

## 5.3 DATA ANALYSIS

Table 5.1 below portrays the outcome of the coding, categorising and theming of the qualitative data.

**Table 5.1: Coding framework**

| Theme | Category | Initial coding |
|---|---|---|
| The climate is changing | Changes in climate | Changes in climate<br>Climate change priority<br>Climate conditions |
| | Sea level | Sea level<br>Rising sea level<br>Disregard (rising sea level) |
| | Location | Location (flood lines, sea front)<br>Location |
| There is a risk inherent in the changing climate | Risk | Risk<br>Take risk into account<br>Quantifying the risk<br>Insurance<br>Negative - low lying areas, sea front, medium to long term<br>Negative influence<br>Because of the risk |
| | When? | Long term<br>Future (change in practice)<br>Future value zero |
| Legislation was promulgated to adapt to or mitigate climate change | Legislation | Professionals from other disciplines<br>Planning and legislation |
| Determining market value in a changing environment | Market (market value) | Market (market value)<br>Past/experience<br>Market value<br>Market value (basis of valuation)<br>Same approach – expert report added<br>Models |
| | | |

Table 5.1 indicates how the qualitative data in the different transcribed interviews was brought together through the different levels of coding. During the first cycle of coding, the holistic coding of the raw data assisted the researcher in combining the broad topic areas together (Saldaña, 2012:118).

In the second cycle of coding, 26 codes were assigned using descriptive coding – see Table 5.1. As indicated in Table 5.1, a third cycle of coding using pattern coding was conducted to categorise the codes and theme the data, as suggested by Saldaña (2012). The initial codes were placed in the following seven categories: changes in climate, sea level, location, risk, long term/future, legislation and market (market value). These seven categories were then reduced to four themes: the climate is changing, there is an inherent risk in the changing climate, legislation was promulgated to adapt to or mitigate climate change and determining market value in a changing climate environment (see Table 5.1).

The data was analysed in the sequence of the questions in the semi-structured interviews. The first section on demographics and the questions of a quantitative nature provided information regarding the participants' age, gender, education, experience and knowledge regarding certain issues. The analysis is presented in a graphical and narrative form.



The qualitative questions in the second, third and fourth sections are presented in a narrative format with verbatim supporting statements from the participants.

## 5.4 PROPERTY VALUERS' DEMOGRAPHICS

In this section, the participants were described according to their demographic profile. Information regarding the participants' age, gender, education and experience was collected to establish if the participants had the characteristics of the wider population.

### 5.4.1 Results on age, gender, education and experience

Table 5.2 summarises the gender, age, experience and qualifications of the property valuers who participated in the research.

**Table 5.2: Participants' property valuation profile**

| *Participant* | *Gender* | *Age* | *Years registered as property valuer* | *Years practising as property valuer* | *Qualifications* |
|---|---|---|---|---|---|
| ***1*** | Male | 66 | 33 | 40 | Baccalaureate degree |
| ***2*** | Male | 67 | 39 | 39 | Grade 12 |
| ***3*** | Male | 65 | 33 | 16 | Baccalaureate degree |
| ***4*** | Male | 76 | 49 | 49 | Diploma |
| ***5*** | Male | 58 | 34 | 21 | Diploma |
| ***6*** | Male | 61 | 6 | 6 | Postgraduate degree |
| ***7*** | Female | 36 | 18 | 2 | Diploma |
| ***8*** | Male | 65 | 28 | 28 | Postgraduate degree |
| ***9*** | Male | 75 | 38 | 38 | Diploma |
| ***10*** | Male | 48 | 20 | 20 | Diploma |
| ***11*** | Female | 41 | 8 | 5 | Diploma |
| ***12*** | Male | 64 | 7 | 7 | Baccalaureate degree |
| ***13*** | Male | 51 | 26 | 15 | Baccalaureate degree |



85% of the participants were male and 15% female. This is in line with the national gender ratio of 82% male and 17% female as stated by the SACPVP (Seota, 2015). According to the SACPVP (Seota, 2015), the majority of registered property valuers are 50 years or older. In this study the researcher found that the majority of the participants were slightly older, i.e. 55 years or older.

The high age is most probably also the reason why three of the participants were registered under the 'mature age clause'. Granting that qualifications are very important for registration with the SACPVP, there are still a number of property valuers registered under the so-called '*oupa* clause'. These are people who practised as property valuers before the establishment of the South African Council for Valuers on 1 January 1983 (South Africa, 1982). However, two participants indicated that they did not have any property-related qualifications. These two entered the valuation profession as building inspectors for the now terminated building societies. One of the participants had only a Grade 12, whereas all the others had at least a higher qualification, with the majority having at least a National Diploma in Real Estate (Property Valuation) or higher and were therefore thought to be well versed in valuation theory.

Only three of the participants had been registered as property valuers for less than 10 years, with the majority registered 20 years or more. The experience of the majority of the participants provided them with opportunities to notice changes along the coast which may be as a result of the changing climate. They are therefore the best-equipped property valuers to express an opinion on the influence of the changing climate on coastal residential real estate along the southern Cape coast.

Figure 5.1 indicates the percentage of the participants who had valued residential real estate in Sedgefield.

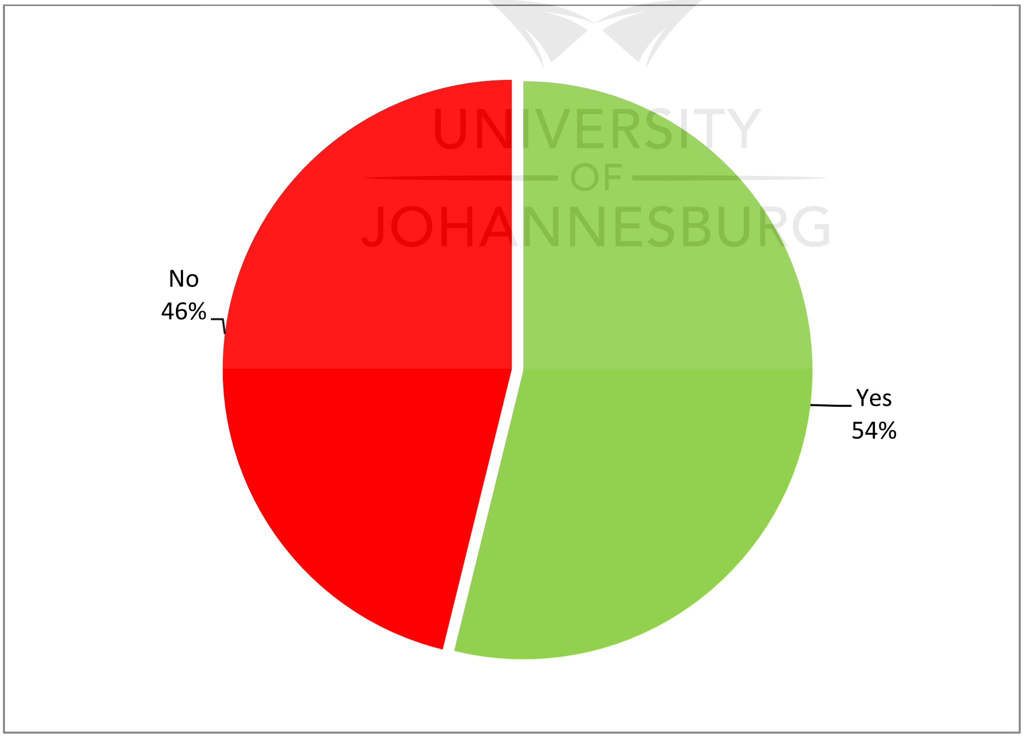


**Figure 5.1: Residential properties valued in Sedgefield**

54% of the participants indicated that they had valued residential real estate in Sedgefield before and were familiar with the area. 46% had not valued real estate in Sedgefield before. Although not all the participants had conducted valuations in Sedgefield, they had conducted valuations in similar areas as indicated below. The participants were therefore familiar with real estate markets under similar circumstances.

Table 5.3 indicates other areas along the southern Cape coast where the participants had valued coastal residential real estate.

**Table 5.3: Residential properties valued in other waterfront locations along the Garden Route**

| Participant | Locations |
|---|---|
| **1** | Plettenberg Bay and surrounds |
| **2** | Knysna, Plettenberg Bay, Nature's Valley, Cape Town, George, Mossel Bay |
| **3** | Knysna valuation roll and country-wide for Rode Group |
| **4** | Herold's Bay, Glentana, Hartenbos, Mossel Bay, Vlees Bay |
| **5** | Mossel Bay, Glentana to Gouritz Mouth |
| **6** | Groot Brak, Klein Brak and Fraai Uitsig |
| **7** | Glentana, Outeniqua and surrounds |
| **8** | Wildernis, Knysna and surrounds |
| **9** | Knysna, Wilderness, Plettenberg Bay and surrounds |
| **10** | Plettenberg Bay, Knysna, Sedgefield, Herold's Bay, Glentana and Vlees Bay |
| **11** | George, Victoria Bay and Herold's Bay |
| **12** | Stilbaai to Nature's Valley |
| **13** | Plettenberg Bay to Mossel Bay |

Table 5.3 presents a list of all the locations along the southern Cape coast where the participants had valued residential properties with a waterfront location. The different locations are indicated on the map in Figure 5.2.


**Figure 5.2: Map of Mossel Bay to Nature's Valley with Sedgefield in centre**

***Source:*** *http://www.portfoliocollection.com/maps/wc-garden-route.gif*

From the map in Figure 5.2, it can be seen that the participants had valued coastal residential real estate along the length of the southern Cape coast.

Hughes (1992) stated that the coastline between Mossel Bay and Nature's Valley is one of the areas most vulnerable to the rise in sea level. Umvoto Africa (2010a) and Theron (2016) confirmed his finding. The areas indicated in Table 5.3 and Figure 5.2 are therefore all considered vulnerable to the rising sea level. The participants thus all had experience conducting valuations of coastal residential properties located in a number of vulnerable areas.

### 5.4.2 Findings on age, gender, education and experience

The demographic profile of the sample is representative of the national population of professional property valuers. The aim of the research was never to generalise and due to the small sample, the researcher will not attempt to do so. The findings did establish that the majority of the participants had 20 or more years' experience valuing coastal residential real estate along the southern Cape coast.

## 5.5 ANALYSIS OF SEMI-STRUCTURED INTERVIEW DATA

The purpose of the semi-structured interviews was to explore the knowledge, behaviour and attitude of selected property valuers regarding the rising sea level in a coastal residential real estate environment, namely Sedgefield. The coding framework in Table 5.1 identifies the four themes which emerged during the analysis of the interviews. The themes are a reflection of what the participants considered when they received an assignment to develop an opinion of value of at-risk coastal residential real estate. The four themes will be presented and discussed below.

### 5.5.1 The changing climate

According to the IVSs, property valuers are responsible '*for the identification of actual or potential environmental risks*' (IVSC, 2013:35). It is therefore important for property valuers to have a basic understanding of climate change and the participants who were practising as coastal residential property valuers were expected to be aware of the rising sea level and associated risks. In section 5.4, it was established that the participants were experienced property valuers with many years of experience along the southern Cape coast.

The aim of this section is to achieve the first research objective, namely to determine whether *the property valuers practising in the coastal real estate market were aware of climate change risk and the consequential risk of a rise in sea level on coastal residential real estate in South Africa.*

The responses in this theme represent the participants' knowledge of and attitudes towards the consequential risk of a rise in sea level along the southern Cape coast.
92% of the participants indicated that they were familiar with climate change. They were also aware of the consequences of climate change. One of the participants stated that he was not concerned about climate change as it would not happen in his

lifetime and he did not consider its impact when he conducted valuations of coastal residential properties.

When the participants were asked to rate their knowledge regarding the possible future consequences of climate change risk, it became apparent that although they were aware of the changing climate, there was no general agreement regarding which of the consequential risks would have the greatest impact on the study area.

Figure 5.3 indicates the property valuers' knowledge of the risk of possible future consequences of climate change in the study area.

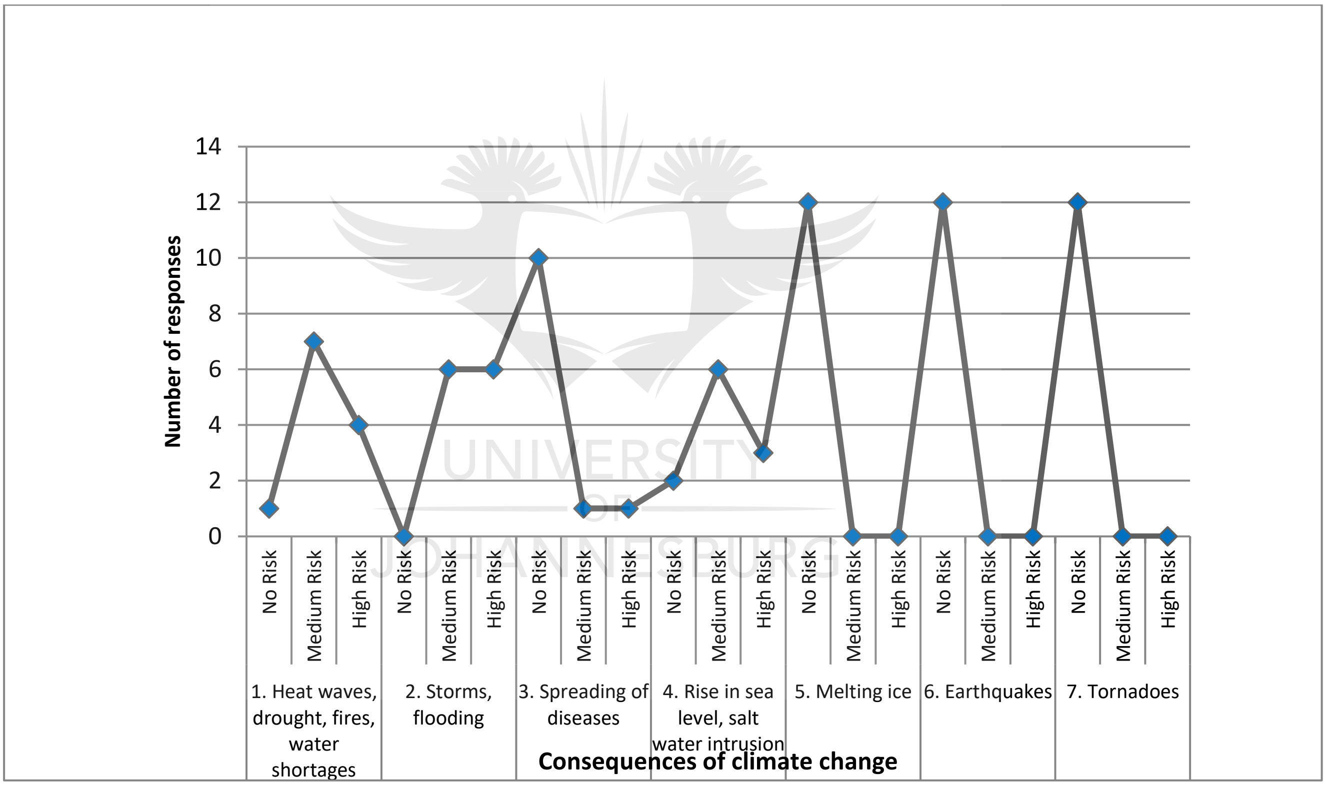


**Figure 5.3: Knowledge of risk of possible future consequences of climate change on southern Cape coast**

The majority of the participants rated heat waves, drought, fires and water shortages as a medium or high risk. There was a 50/50 division between the participants regarding the risk rating for storms and flooding.

The participants' rated the rise in sea level and saltwater intrusion as no risk (15%), medium risk (46%) and high risk (23%), and 16% did not rate it at all. This was unexpected as the interview was about the influences of the rising sea level on coastal residential real estate. The researcher assumed that the title of the study would have alerted the participants to the potential influence of the rising sea level on coastal residential real estate.  The reason for these responses could be that participants simply ignored the rising sea level, as it has not happened yet. This is confirmed in Figure 5.4.

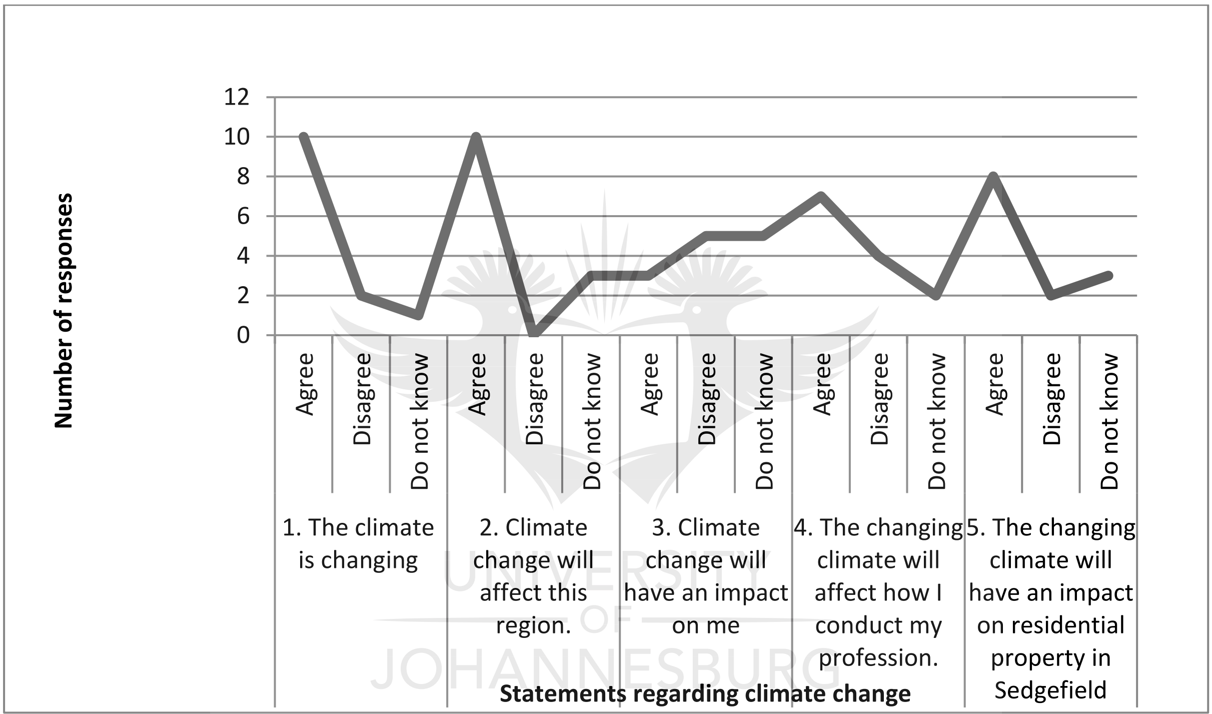


**Figure 5.4: Participants' views on changing climate**

Figure 5.4 indicates the participants' views regarding climate change. The participants were asked to agree or disagree with five statements which reflected their views of climate change.  The majority (ten) of the participants agreed with the statements 'The climate is changing' and 'Climate change will affect the southern Cape coast'. Only three participants agreed that climate change would have an impact on them and the others disagreed or did not know. Seven participants agreed that the changing climate would affect how they conducted their profession and eight agreed that It would have an impact on residential property in Sedgefield. These responses indicate that the majority of the participants believed that the changing climate would have an influence on how they conducted their profession from day to day.

It was then established whether participants had noticed any changes in the environment that could be attributed to climate change. The responses varied from '*climate change has always existed - but not as severe as forecasted'* (P2) to '*I would say the sand dunes here where we are, are being washed away or are collapsing'* (P13). Two respondents specifically referred to the rising sea level '*Yes, rising sea levels damaging front row properties*' (P7) and '*all the houses in Herold's Bay will be below water ... The sea has been so high it went over the top*' (P4).

This indicates that the participants were aware of the changing climate, but there were different levels of awareness. When asked in question B7 if their observations were based on personal observations or scientific evidence, the unanimous response was personal observations.

After establishing that the participants were aware of the direct effects of climate change, i.e. the rising sea level, on real estate, their knowledge regarding the effect of climate change on the local economy and the legal environment was investigated. Both the economy and legislation influence the value of real estate. It is therefore important to consider the impact of the changing climate on the economy of a coastal region as well as the impact of legislation promulgated to adapt to or mitigate the effect of climate change.

Figure 5.5 reveals the participants' views on the effect of climate change on the economy of the southern Cape coast.

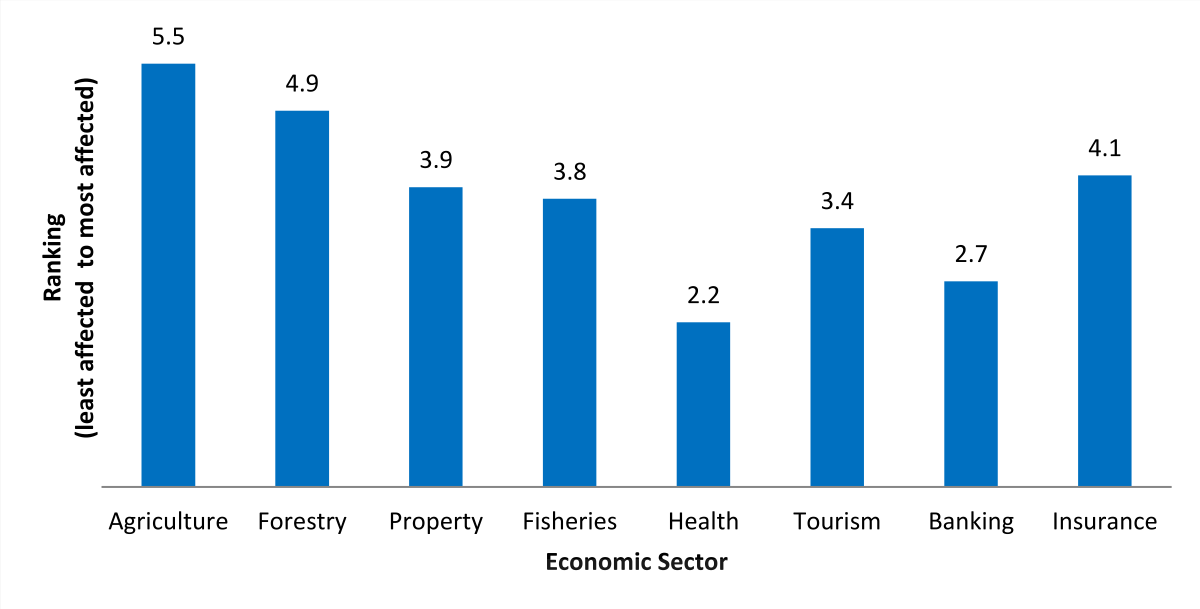


**Figure 5.5: Property valuers' views on effect of climate change on economic sector**

SARVA (South Africa, 2010) indicates that the agriculture, banking, fisheries, forestry, health, insurance, property and tourism sectors will be affected by the changing climate. The participants were asked to rank the impact of the changing climate on the economic sectors as identified by the Department of Environmental Affairs on the southern Cape coast from least to most affected. According to the participants, the biggest risk from the changing climate will be on the agricultural, forestry and insurance sectors of the economy in the study area. This opinion of the participants was based on their own experience working in the southern Cape. The researcher did not find any evidence that the participants were aware of the latest literature regarding the effect of the changing climate on the study area.

Figure 5.6 indicates the participants' awareness of measures taken by institutions/individuals to adapt to or mitigate climate change.

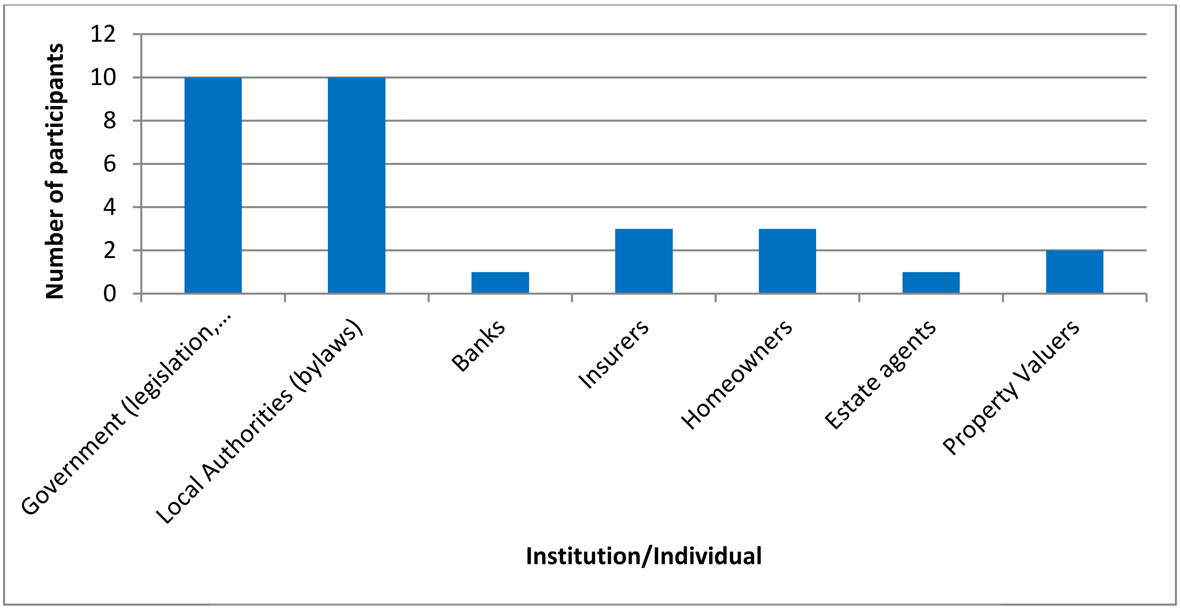


**Figure 5.6: Participants' awareness of measures taken by institutions/individuals to adapt to or mitigate climate change**

Ten of the participants were aware of measures taken by government and local authorities to mitigate the influence of climate change. Only three participants were aware of similar measures from banks, insurers, homeowners, estate agents and property valuers. None of the participants provided any evidence to substantiate their opinions. The researcher is therefore inclined to believe that their opinions were based on personal observation and not on scientific evidence.

Having indicated that they were aware of measures taken by the government and local authorities regarding climate change, the participants were asked if they considered these measures when they conducted valuations. 54% indicated that they did.

During the interviews one of the participants indicated that he considered the distance of the property from the shore during high water and the *'50 & 100 year flood lines'* (P2), while P6 considered the *'location of the property relevant to flood or sea risk areas'*. P3 indicated that he was aware of the effect of what was happening on the beachfront: '*I would say the sand dunes here where we are, are being washed away or are collapsing*'.

The majority of the participants, 62%, claimed that they considered the rising sea level when they conducted valuations of coastal residential properties. One of the participants was quite direct: '*Yes, rising sea levels damaging front row properties*' (P7) and '*at Herolds Bay the houses down there will be under water'* (P7) (researcher's translation). Although the majority of the participants claimed that they would consider the rising sea level when they conducted valuations of coastal residential properties, not even one clearly indicated how they would do this or how they would quantify the inherent risk. None of the participants referred to specific legislation.

On closer examination, it became apparent that although the participants were aware of the changing climate, they relied on past events and experience to inform their current behaviour. Two participants indicated that the market dictated and that they followed the market when they valued property: '*at the end of the day we still have to look at what the market dictate*' (P10) and '*Yet, sales still remain the indicator of market value, the amount he should have obtained, comparable sales'* (P11). This undoubtedly indicates that property valuers working along the southern Cape coast currently ignore the impact the changing climate and specifically the rising sea level will have on the market value of coastal residential real estate.

### 5.5.2 Risk inherent in the changing climate

Having established the property valuers' perceptions of the changing climate and the rising sea level in theme 1, how valuers applied this knowledge in practice is explored in theme 2.

The second theme that emerged during the analysis of the interviews was the agreement among participants that the changing climate presents a risk to coastal residential real estate. Two broad categories contributed to this theme: the risk and when the risk will take effect.

The risk can be divided into primary risk, i.e. risk directly related to the changing climate, and secondary risk, i.e. risks that stem from the primary risk.

During the interviews the participants identified the primary risks as properties situated '*dangerously close to the water*' (translation) (P3), '*periodic flooding*' (P2), '*the rising sea level*' (P2), '*strong winds which cause erosion*' (P5) and '*rising sea levels, floods and water shortages*' (P6).

Responses of financial institutions and insurers to the changing climate are secondary risks, which may influence the value of coastal residential properties. Figure 5.6 indicates the property valuers' opinions regarding financial institutions' consideration of the rising sea level during the mortgage application process.

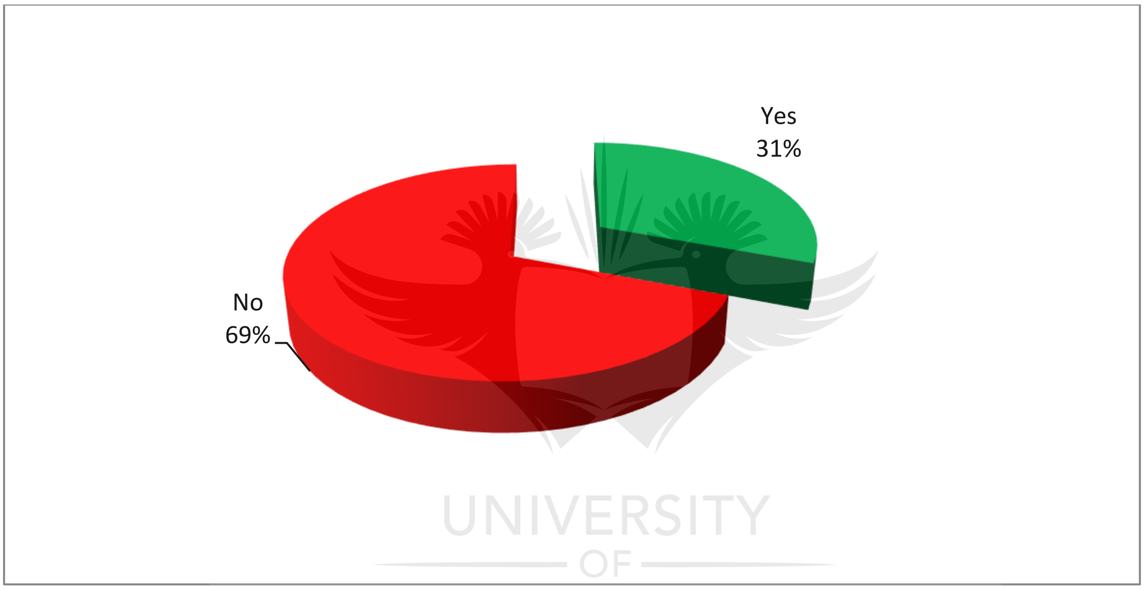


**Figure 5.7:** **Whether financial institutions consider rising sea level during mortgage application process**

Figure 5.7 reveals that 69% of the participants were of the opinion that financial institutions did not consider the approaching risk inherent in the rising sea level, i.e. the primary risk, when they considered mortgage applications. Financial institutions are the largest employer of property valuers on the southern Cape coast and although none of the participants were employed full time by a financial institution, the majority were contracted to conduct valuations for financial institutions from time to time.

According to the participants, secondary risks are not that implicit, as a financial institution '*will set more stringent loan requirements or just decline the application*' (translation) (P12). Three of the participants referred to financial institutions: '*what* *bonds are already registered under the property and if they are reasonable or not'* (P1) and '*Will listen to any concerns they might have and make a call*' (P7). Some of the participants voiced strong opinions regarding the insurer's actions: '*The value is influenced by the insurance cover or no cover*' (P5) and *'It's got to marginalise the value of the property if no-one's willing to insure it*' (P9). Figure 5.8 illustrates the property valuers' opinions on how insurers mitigate the risk of rising sea level.

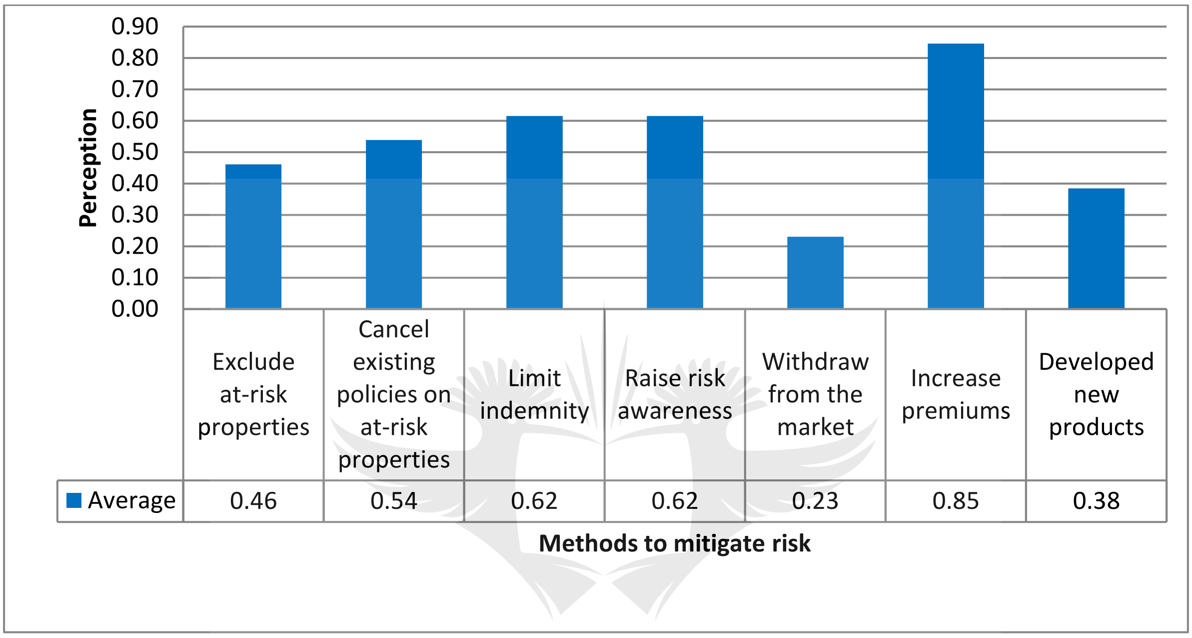


**Figure 5.8: How insurers mitigate SLRR**

Figure 5.8 indicates that the participants were of the view that insurers will begin by increasing insurance premiums, and then raise risk awareness by limiting their indemnity before they will exclude at-risk properties in an attempt to mitigate the risk of rising sea level.

Figure 5.9 reflects the participants' response to the question whether property valuers considered the actions of financial institutions and insurers regarding at-risk properties.

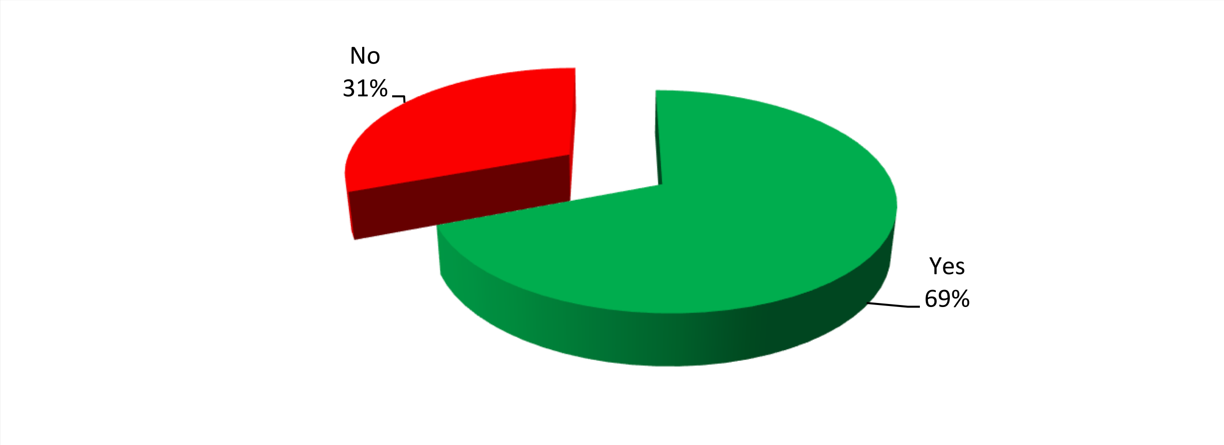


**Figure 5.9: Participants' consideration of actions of financial institutions and insurers regarding at-risk properties**

It was evident that the decisions of financial institutions and insurers did influence property valuers' decision-making. P5 pointed out: '*That value is influenced by the insurance cover or no cover*'. Another participant declared '*It's got to marginalise the value of the property if no-one's willing to insure it*' (P9).

Although some participants indicated that they considered the SLRR when they developed an opinion of value, they did not explain how they did so and their comments ranged from '*will take periodic flooding into account'* (P2), '*will definitely have a much lower value'* (translation) to '*Will maybe deduct an amount for the future risk involved'* (P7) and '*You will have to discount that value*' (translation) (P10). Some of the participants made equivocal suggestions: '*maybe deduct an amount'* (P7), '*discount that value*' (P10), '*discount it as if you are writing it off over twenty years*' (P13).

None of the participants clearly explained how they would quantify SLRR. However, two participants did point out that the actions of financial institutions and insurers could not be used to determine market value: '*you value on comparative sales that is the only real way to value is comparative sales and take into account the market'* (P1) and '*No. For me it has nothing to do with market value*' (P13).

Figure 5.10 indicates the property valuers' opinion on the use of increasing insurance premiums as a proxy to identify risk.

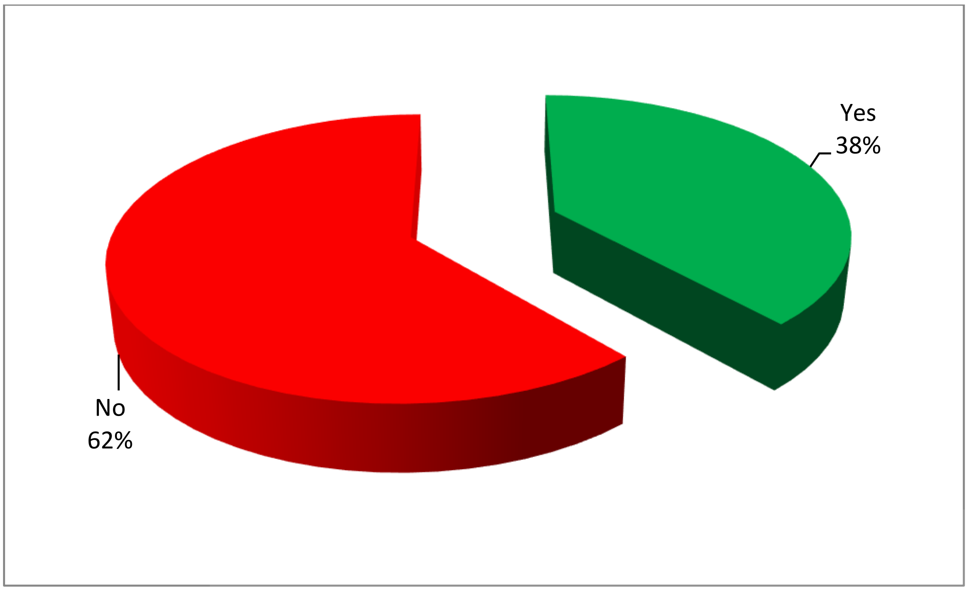


**Figure 5.10: Increasing insurance premiums as proxy to identify risk**

According to Figure 5.10, the majority of the participants did not use insurance premiums as a proxy to identify risk. On further investigation, five of the participants indicated that they would use insurance premiums as a proxy to identify risk: "*No insurance no value"* (P1), "*Yes for example the insurance premiums in Klein Brak are very high" (P5)* and *"Escalated expenditure/costs to a property - which will make it more expensive to live in and probably decrease demand" (P7).*

Other participants acknowledged the negative impact of low-lying areas: *"Low lying areas will be affected more especially by flooding*" (P5), "*Be more careful and aware of low lying properties close to rising water levels and future costs involved*" (P7).

Although the participants acknowledged the risks, storms and flooding, rise in sea level and saltwater intrusion, they were of the opinion that these would not have an effect in the short term: "*it will influence it, yes, absolutely in twenty years, but if we say near future that is two to three years, no*" (P9), "*I think it will be medium to long term before you … realise the impact thereof and it becomes visible in values*" (P10).

The last statement reflects the participants' views that they would include SLRR when they developed an opinion of value only if such risk were reflected in the real estate market.

### 5.5.3 Legislation promulgated to adapt to or mitigate climate change

The third theme that emerged was the participants' lack of knowledge regarding the legislation promulgated to adapt to or mitigate climate change.

Figure 5.11 indicates the participants' knowledge regarding legislation that affects coastal residential real estate.

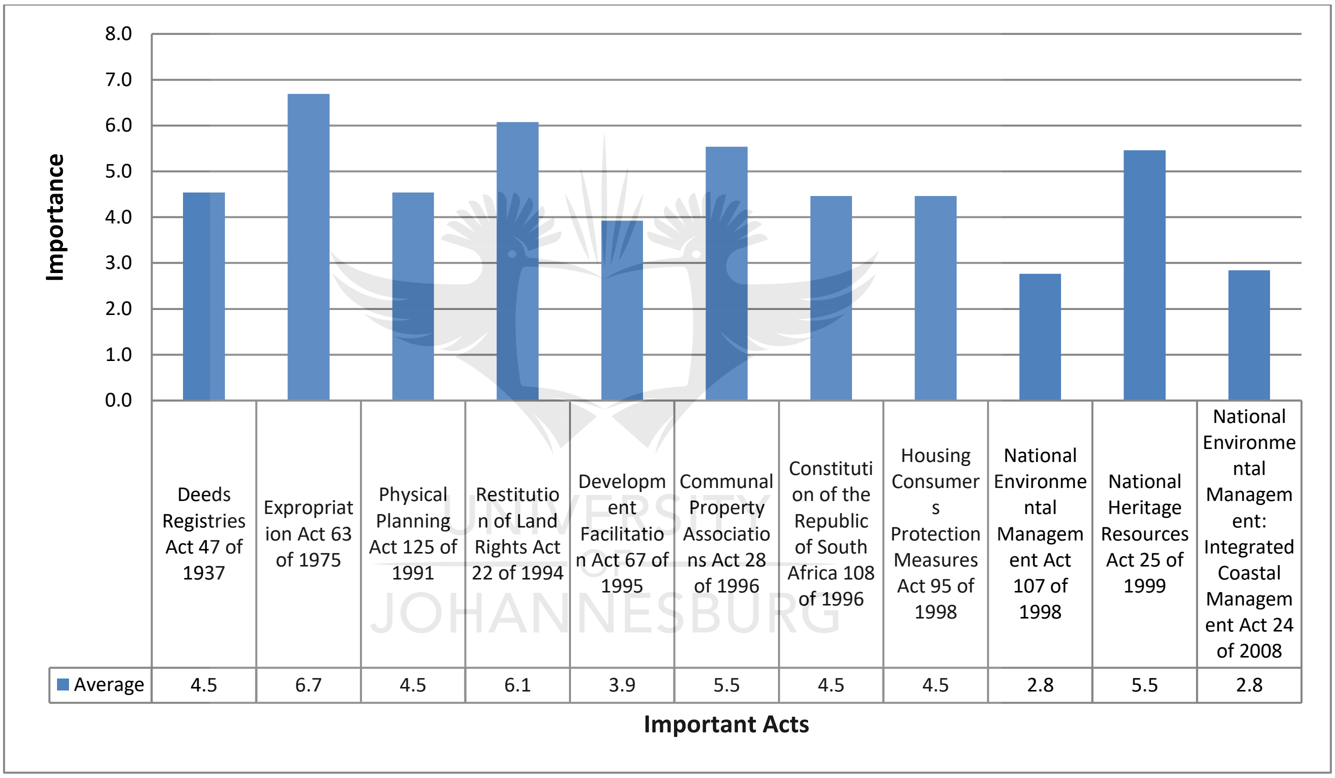


**Figure 5.11: Knowledge of legislation, which may influence coastal residential property**

The participants were provided with a list of Acts which have an impact on real estate and were asked to rate them in order of importance. The Expropriation Act was rated as the most important, followed by the Restitution of Land Rights Act. The environmental legislation was the National Environmental Management Act 107 of 1999 (NEMA) and the ICM Act, which were rated as the least important according to the participants.

Although the participants had many opportunities to comment on the impact of legislation, no one did. None of the participants indicated that they were aware of the detrimental conditions which have a direct impact on coastal property as listed in the ICM. One participant did mention that in certain circumstances they would consult with an environmental specialist (P9).

Even though the majority of the participants indicated that they were aware of measures taken by government and local authorities, only one participant referred to *'future planning and legislation regarding town planning*' (P7). He did not expand on his statement and not a single respondent referred to the environmental legislation mentioned above. Three participants indicated that they were aware of similar measures from banks, insurers, homeowners, estate agents and property valuers. However, they did not expand on their statements.

The researcher concluded that the participants were unaware of the implications of the latest legislation promulgated to adapt to or mitigate climate change.

### 5.5.4 Determining market value in a changing climate environment

From the previous section, it is apparent that the participants' knowledge regarding environmental legislation and its impact on real estate was lacking. The participants had distinct positions regarding how they developed opinions of value: '*you value on comparative sales that is the only real way to value*' (P1), *'No I disagree. It still stays market value … on the comparable sites'* (P13), '*the basis of valuation is market value*' (P9) and '*In this area the basis of valuation is still market value*' (translation) (P11). Market value is the basis of valuation for the majority of valuations being conducted. The physical characteristics of property are one of the main contributors of value. Figure 5.12 indicates the physical characteristics of property considered by property valuers.

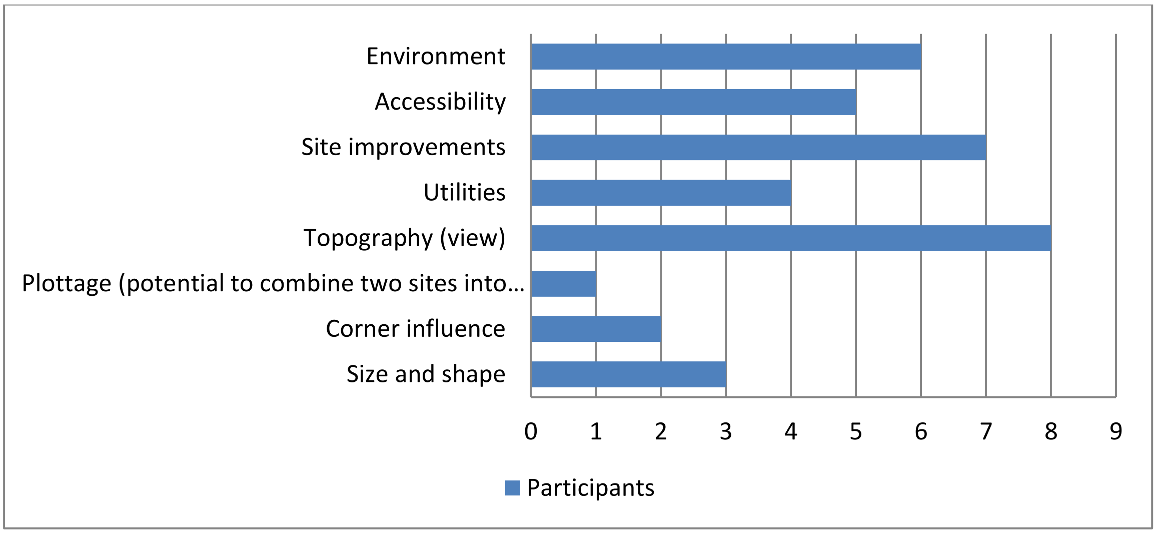


**Figure 5.12: Physical characteristics of property considered**

The participants ranked topography, the environment and the improvements on a specific site as the most important physical characteristics of property. This is valid as recreation is one of the major reasons for purchasing coastal residential real estate.

The importance of environmental influences on a purchaser's decision-making is illustrated in Figure 5.13.

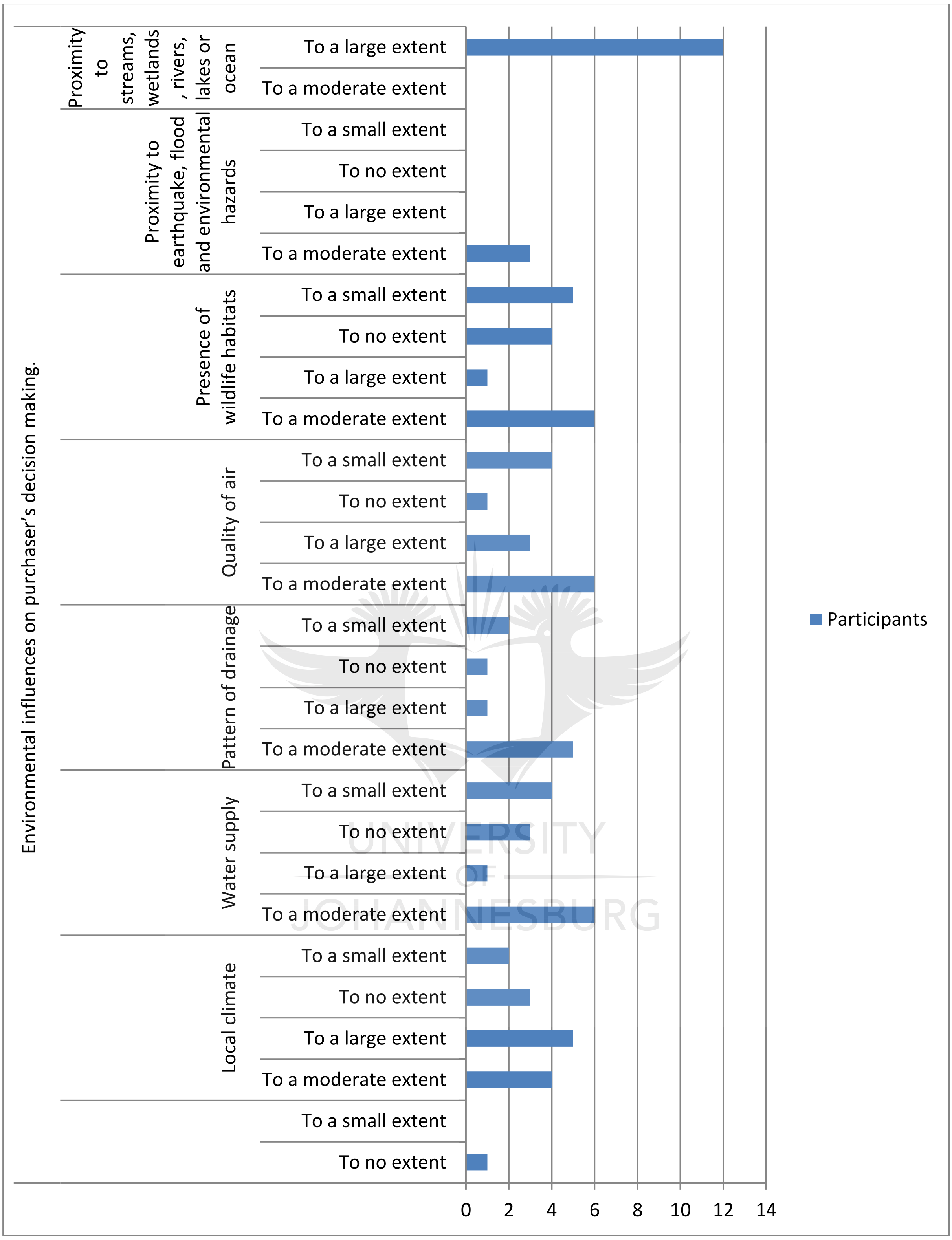


**Figure 5.13: Environmental influences on purchaser's decision-making**

Figure 5.13 indicates that the majority of the participants were of the opinion that proximity to streams, wetlands, rivers, lakes or the ocean largely influenced a purchaser's decision-making, whereas earthquakes, floods and environmental hazards were insignificant.

The impact of the proximity to streams, wetlands, rivers, lakes or the ocean was further interrogated by asking the participants to explain how they would conduct a hypothetical valuation of an at-risk property in the study area. They were given the following scenario: *'The subject property is situated on Sedgefield Island a suburb of Sedgefield, on the Swartvlei estuary. It is one metre above sea level, the sea is rising at a rate of fifty millimetres per annum, and thus the property will probably be below sea level in 20 years' time*.'

The responses were quite diverse: *'I don't think I would consider the rising sea level as an influence but I would definitely consider the susceptibility to flooding*' (P2), '*I will not take it into account … I have not picked it up in the market*' (P3), '*I will not take that into consideration at all'* (P4), *'I will still use the same method*' (translation) (P12) and '*I will use the normal way, because every valuation has an effective date*' (translation) (P12). Others considered the future impact: '*The residual value of the property after 20 years will be zero. Therefore, the annual value based on the rental income (permanent rental or holiday rental) for the period should be taken into account'* (P6) and '*Will maybe deduct an amount for the future risk involved, but it will be difficult to judge how big the impact will be on a valuation. Insurance and bank opinion will also contribute to this'* (P7). Some of the participants put forward solutions to the problem: '*Therefore the annual value based on the rental income (permanent rental or holiday rental) for the period should be taken into account'* (P6) and '*Will maybe deduct an amount for the future risk involved'* (P7).

The responses reveal a number of different opinions that range from no response to deducting an amount for the future risk. This raises questions regarding the basis of valuation that participants applied. Figure 5.14 indicates participants' opinions regarding changes to the basis of valuation.

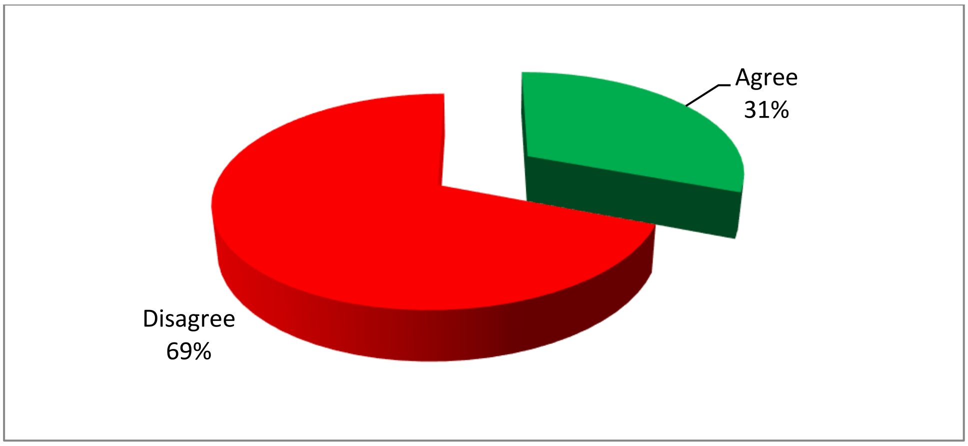


**Figure 5.14: Changes to basis of valuation**

Figure 5.14 indicates that the majority of the participants disagreed with the statement: “The expected rise in sea level has changed the basis of valuation property valuers used to determine the market value of coastal residential property”, while a third agreed with the statement.

The basis of valuation was then further interrogated when the participants were asked to motivate their opinion regarding making changes or no changes to the basis of valuation with rising sea levels.

The responses varied from ‘*No I disagree; because we haven’t seen anything of it yet’ (P2)* and *‘No. I don’t think it changes the definition of market value to me ... The basis of valuation is market value,’ (P9)* to ‘*Not at the moment but will in future. Taken into consideration in certain areas’ (P5)* and ‘*To a certain extent you will have to consider the location of the site/improvements and the rising water levels and not just comparables’ (P7).*

The participants were of the opinion that they did not have to respond to the threat of climate change at this time, ‘*I don’t know – not in my lifetime*’ (P1), ‘*Only when the market starts reacting to the specific risk to the property*’ (P3), ‘*Must be taken into account in the future*’ (P5) and ‘*The market determines the value*’ (translation) (P10). This was confirmed by another participant: ‘*The principles of valuation will not change … because a purchaser will take these into account*’ (P9). P6 admitted that ‘*comparable market transactions will not be sufficient*’ and another participant stated it bluntly that he would not consider it '*unless there can be a very well reasonable and thought out protocol for it*' (P2). Other responses in this regard were that there should be a change in '*policy*' (P11) and the rising sea level should be included in the template of the property valuer's report (P12). The participants were of the opinion that the basis of valuation would remain market value, which implies that they would continue applying the comparable sales approach. Some of the participants did admit that sale transactions might not be sufficient to develop an opinion of value. It was for this reason that the researcher decided to investigate the participants' knowledge and application of pricing models. The use of multiple regression and hedonic pricing models by property valuers is indicated in Figure 5.15.

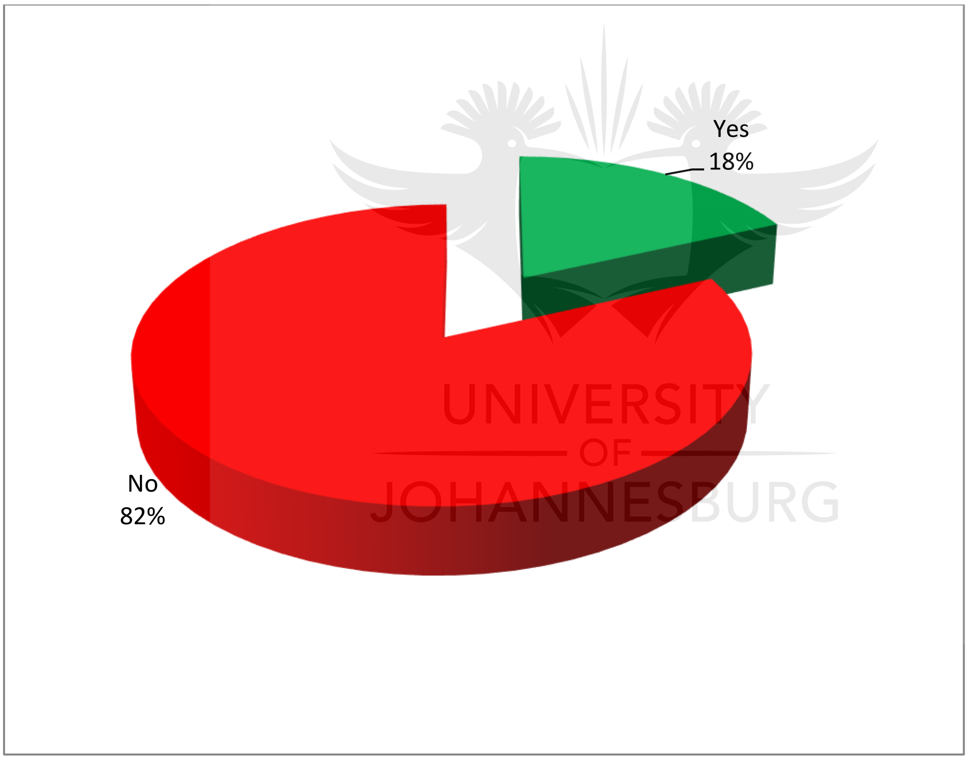


**Figure 5.15: Use of multiple regression and hedonic pricing models**

Figure 5.15 indicates that the majority of the participants did not use multiple regression or hedonic pricing models when they conducted valuations. Only three participants had used multiple regression in the past and none had used hedonic pricing models. However, the participants did indicate that they relied on the views of experts.

Figure 5.16 indicates the use of expert views as proxies to value properties.

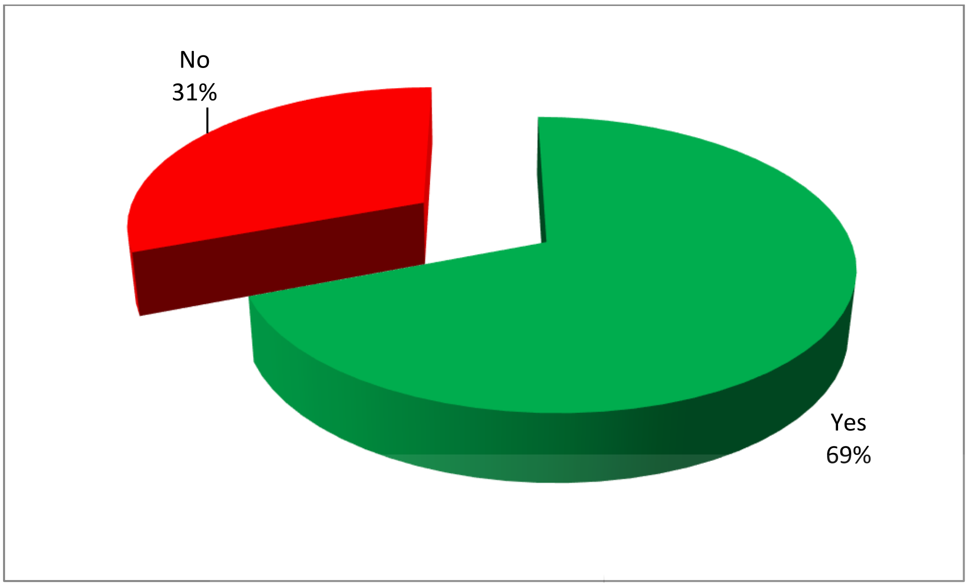


**Figure 5.16: Participants applying expert's opinion as proxy to value property**

Figure 5.16 shows that the majority of the participants used expert views as proxies when they conducted valuations. Closer examination revealed that the experts' views were not used as proxies for value but rather to resolve specific problems: '*Definitely; engineers and surveyors and stuff'* (P1), *'Town planners and engineers, especially with properties below the flood lines'* (P5) and *'Speak to environmental experts & town planning until you understand the surrounds and the impact of certain risk areas'* (P7).



From the review about climate change, it appears that the participants were waiting for changes in the market before they reacted to the threat created by the changing climate. Bienert et al. (2008) warn that property valuers will have to include the declining future benefits of an investment in property. Some of the participants were clearly looking for guidance to assist them when dealing with climate change risk.

## 5.6 SUMMARY

The aim of the study was to investigate the predicted effect and ensuing risk of a rise in sea level on the valuation behaviour of property valuers in the coastal residential market in order to design a model that can be used to estimate a risk premium for coastal residential real estate. Although the intention was never to generalise due to the small sample, the findings did establish that the majority of the participants had 20 or more years' experience in valuing coastal residential real estate along the southern Cape coast.

The conclusion is that although the participants had noticed changes in the environment, they did not necessarily attribute them to climate change and generally considered climate change as something that would happen in the future. They believed that the risks associated with the changing climate would only have an influence on value in the distant future. It was evident that the participants' knowledge regarding legislation and its impact was limited. The participants clearly stated that as long as they did not find evidence of climate change in the market, they would disregard the effect of climate change on the value of coastal residential properties. The researcher concludes that the participants were unaware of implications of the latest legislation promulgated to adapt to or mitigate climate change.

The qualitative phase of the study generated the following hypotheses:

*$H_0$: There is no relationship between property valuers' disregard of the risk of sea level rise associated with climate change and the impact it has on the value of coastal residential properties in Sedgefield, South Africa.*

*$H_a$: There is a relationship between property valuers' disregard of the risk of sea level rise associated with climate change and the impact it has on the value of coastal residential properties in Sedgefield, South Africa.*

Testing of the hypotheses will be described in chapter 6 through the statistical analysis of empirical evidence, i.e. selling price data over 20 years from two areas in Sedgefield.

# CHAPTER 6

# ANALYSIS OF SEDGEFIELD SELLING PRICES

## 6.1 INTRODUCTION

In the previous chapter the results of the first stage, which dealt with the qualitative research in this mixed methods design, were reported and hypotheses were developed. The aim of this chapter is to test the following hypotheses:

$H_o$: There is no relationship between property valuers' disregard of the risk of sea level rise associated with climate change and the impact it has on the value of coastal residential properties in Sedgefield, South Africa.
$H_a$: There is a relationship between property valuers' disregard of the risk of sea level rise associated with climate change and the impact it has on the value of coastal residential properties in Sedgefield, South Africa.

Sea level rise risk is affected by three variables, namely height above mean sea level, distance from the water and flood events. To test the hypotheses stated above, the dependent variable, i.e. the selling price of properties sold more than once in the past 20 years, was compared to the independent variables (height amsl, distance from the water and flood events). A separate hypothesis was developed and tested for each independent variable. A null and alternative hypothesis was developed for each of the three hypotheses.

Hypothesis 1. $H_0$: There is no relationship between height above mean sea level and the selling price of coastal residential properties in Sedgefield.
$H_a$: There is a relationship between height above mean sea level and the selling price of coastal residential property in Sedgefield.

Hypothesis 2. $H_0$: There is no relationship between distance from the high-water mark and the selling price of coastal residential property in Sedgefield.

$H_a$: There is a relationship between distance from the high-water mark and the selling price of coastal residential property in Sedgefield.

Hypothesis 3. $H_0$: There is no relationship between flood events during the past 20 years and the selling price of coastal residential property in Sedgefield.

$H_a$: There is a relationship between flood events during the past 20 years and the selling price of coastal residential property in Sedgefield.

By using sales data from the property market in Sedgefield, it was possible to establish if the knowledge, attitudes and behaviour of market participants (purchasers and sellers) are reflected in current market behaviour. The participants in this research stated that they relied on past market data to develop an opinion of value. If the market participants acted knowledgeably, prudently and without compulsion as stated in the definition of market value (Appraisal Institute, 2008), their behaviour should be reflected in the market data of the Sedgefield property market.

## 6.2 DATA ANALYSIS STRATEGY

Secondary sales data for Sedgefield was used in the property sales analysis. Sales data, the dependent variable, for the last 20 years was obtained from a database called Property Intellect through the University of Johannesburg library. Property Intellect is a database that acquires property data directly from the deeds office, cleans the data and then provides it to individual users in a user-friendly format. The data from the deeds office is reliable as all property transactions in South Africa are recorded in the deeds office after a thorough verification process (South Africa, 1937). According to Property Intellect, the deeds property list for Sedgefield indicates that there were 4 214 properties in Sedgefield. The purpose of using the sales data was to establish if property valuers' behaviour regarding the changing climate is consistent with the behaviour of purchasers and sellers in Sedgefield's property market. A secondary purpose was to establish if there are any noticeable trends that might indicate changes in the property market that can be linked to changing climate events.

### 6.2.1 The study area

The population of this study included all coastal residential properties along the southern Cape coast from Mossel Bay to Nature's Valley. Purposive sampling was used to identify the study area and control area in Sedgefield.

Figure 6.1 indicates the location of the study area on the southern Cape coast.


**Figure 6.1: Map of Mossel Bay to Nature's Valley with Sedgefield in centre**

***Source:*** http://www.portfoliocollection.com/maps/wc-garden-route.gif

Sedgefield is situated approximately in the middle of the southern Cape coast, which stretches from Mossel Bay in the west to Nature's Valley in the east. Hughes (1992) and Umvoto Africa (2010a) identified it as one of the areas most vulnerable to the rising sea level.

Figure 6.2a and 6.2b indicate the normal situation and Figure 6.3 indicates the extent of the flood in 2007.

**Figure 6.2a: Sedgefield Island**

***Source:*** *Photo taken by researcher on 29 September 2015*



**Figure 6.2b: Sedgefield Island**

***Source:*** *Photo taken by researcher on 29 September 2015*

**Figure 6.3: Sedgefield Island during 2007 flood**
***Source:*** *Anon (2007)*

### 6.2.2 Data collection

From the study area, two sites – one called the study site and the second called the control site – were identified. Figure 6.4 shows the two sites.


**Figure 6.4: Study and control sites**

***Source:*** *Google Earth (2015) with researcher's demarcations in red*

The study site (constituting at-risk properties), Sedgefield Island, is situated on the banks of the Swartvlei Estuary below the 5 m amsl line and is exposed to regular flooding and the rising sea level. The control site (constituting not at-risk properties) is also on the banks of the Swartvlei Estuary, but 20 m or more above the current mean sea level and it has not experienced any form of flooding. The study site is vulnerable to the rising sea level but the control site is not. The two sites were chosen to establish if there is a difference between the market behaviour of purchasers and sellers in the study site and the control site.

### *6.2.2.1 The study site, at-risk properties*

The Sedgefield valuation roll and the municipal map of Sedgefield Island were used to identify the erf numbers of all the residential properties in the suburb known as Sedgefield Island. There were 565 residential erven in Sedgefield Island, which amounted to 13% of the total erven in Sedgefield.

In Sedgefield Island, 78 of the 565 properties that were sold twice or more were identified and listed on a spreadsheet in order to analyse them statistically.

The height above mean sea level (independent variable 1) as well as the distance from the water (independent variable 2) were included on the spreadsheet. The height amsl and the distance from the water are risk factors affected by the rising sea level.

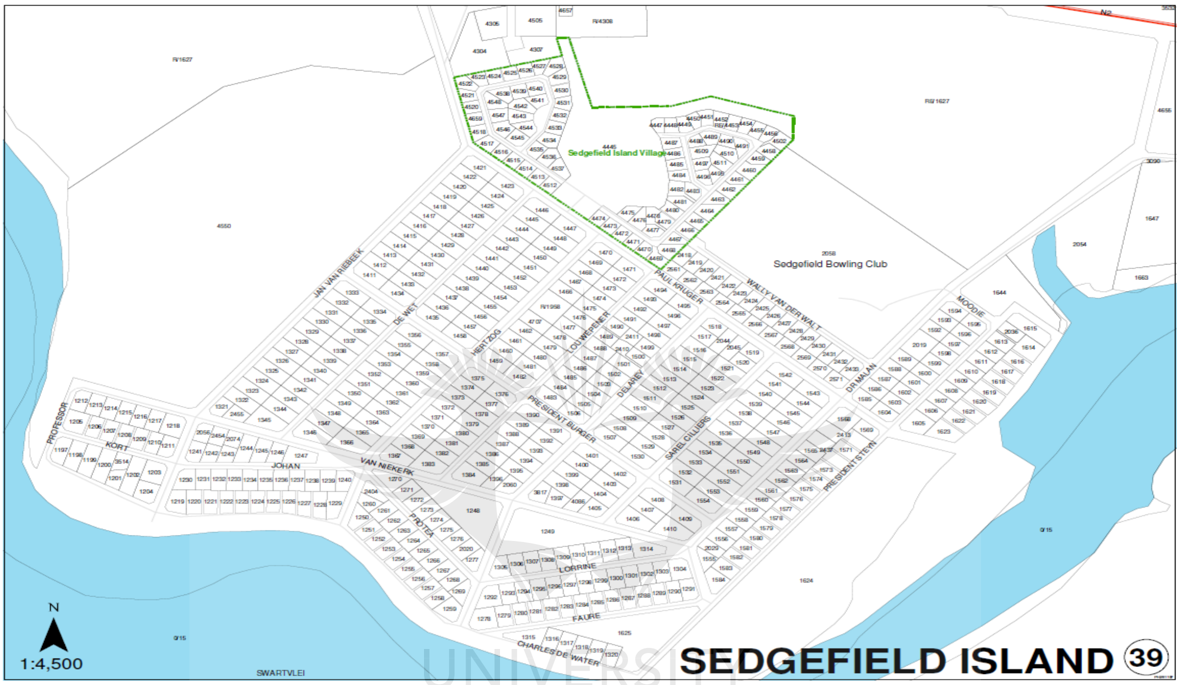


**Figure 6.5: Sedgefield Island**

***Source:*** *Knysna Municipal Map Book* (Knysna Municipality, 2007)

The township map of the study area, Figure 6.5, is a graphic illustration of the area indicating the proximity of the erven to the water. This map and Google Earth was used to identify the repeat sales and to determine the height above sea level and distance from the water of the affected erven.

### *6.2.2.2 The control site (Sedgehill), not at-risk properties*

The control site, Sedgehill, was purposefully selected based on its height amsl. The height amsl was selected so that the properties would not be affected by rising sea level or flooding. This control site is on average 20 m amsl but still in close proximity to the Swartvlei Estuary.

Figure 6.6 shows the control site.

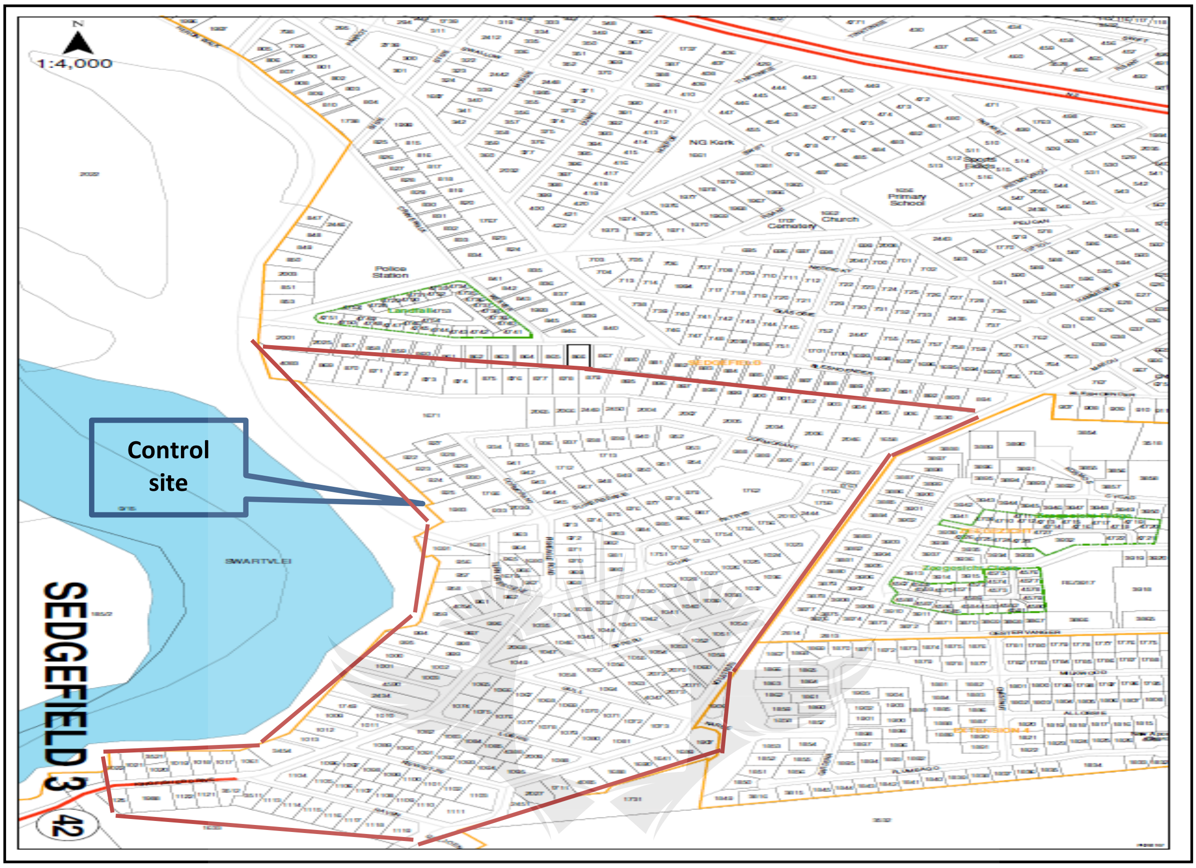


**Figure 6.6: Control site, Sedgehill**

***Source:*** *Knysna Municipality (2007)*



There are fewer erven in the control site (239), Sedgehill, because parts of the area to the north of Cormorant Street and east of Volstruis Street were excluded. Cormorant Street is on top of a large and long hill dividing the area into two distinct areas. The area to the north and foot of the hill are not as high above mean sea level as the area to the south that forms part of the control site. The erven to the east of Volstruis Street are in close proximity to Smutsville and Sizamile, which has a negative impact on the value of those erven. These 239 erven in the control site represent 6% of the registered properties in Sedgefield and 25% had been sold more than once over the past 20 years (see Figure 6.6).

## 6.3 DATA ANALYSIS

Sales data (dependent variable) from 1994 to 2015 was collected for the study and control sites. The collected data was cleaned and all incomplete transactions and transactions that were not arm's-length transactions were removed. Of the refined property sales, only properties which had been sold more than once were included in the list of sales for further analysis.

The selling prices were then standardised by adjusting the selling prices with the Consumer Price Index (CPI) to 2012/12 = 100. The last time the South African Reserve Bank made an adjustment to standardise the CPI was in December 2012 (South African Reserve Bank, 2015).

A logarithmic (Log 10) transformation of the data was performed to interpret and recognise patterns in the property sales data (Howell, 2007; Tabachnick & Fidell, 2007, and Owusu-Anash, 2011). According to Howell (2007), Tabachnick and Fidell (2007) and Owusu-Anash (2011) substantially negative skewed data should be transformed logarithmically (Log 10) to improve the interpretability of the data.

Three data sets, namely the raw selling price, the adjusted selling price and the transformed adjusted selling price, are shown in the tables 6.1 and 6.2. Both the adjusted selling price and the transformed adjusted selling price are reported.

### 6.3.1 Descriptive statistics

Descriptive statistics, see Table 6.1 below, were applied to determine if the selling prices of the study site, Sedgefield Island and the control site in Sedgefield could be compared.

**Table 6.1: Frequency distribution**

| Statistics | | | | | |
|---|---|---|---|---|---|
| Group | | | Raw selling price | Adjusted selling price 2012/12 = 100 | Transformed adjusted selling price 2012/12 = 100 |
| Study site (Sedgefield Island) | N | Valid | 191 | 191 | 191 |
| | | Missing | 0 | 0 | 0 |
| | Mean | | 678484.71 | 967937.27 | 5.8725 |
| | Median | | 500000.00 | 817610.06 | 5.9125 |
| | Mode | | 1300000 | 1512739 | 6.18 |
| | Std. deviation | | 551441.854 | 671186.738 | .33260 |
| | Skewness | | .988 | 1.070 | -.328 |
| | Kurtosis | | .350 | 1.114 | -.699 |
| | Minimum | | 43000 | 112705 | 5.05 |
| | Maximum | | 2500000 | 3782148 | 6.58 |
| Control site (Sedgefield) | N | Valid | 154 | 154 | 154 |
| | | Missing | 0 | 0 | 0 |
| | Mean | | 837734.71 | 1195412.10 | 5.8891 |
| | Median | | 585500.00 | 876795.45 | 5.9427 |
| | Mode | | 700000 | 1104101 | 6.04 |
| | Std. deviation | | 870290.949 | 1312481.689 | .43101 |
| | Skewness | | 2.018 | 4.119 | -.476 |
| | Kurtosis | | 5.176 | 26.673 | .483 |
| | Minimum | | 16000 | 32675 | 4.51 |
| | Maximum | | 5100000 | 11604585 | 7.06 |

The analysis of the study and the control sites indicated no statistically significant difference between the two sites.

There was no missing data and no significant difference in scores between the study site mean (M) = 967937.27, standard deviation (SD) = 671186.738 / M = 5.8725, SD = .33260) and the control site (M = 1195412.10, SD = 1312481.689 / M = 5.8891, SD

= .43101). The differences between the mean and the standard deviation of the two sites were very small and it is therefore possible to compare the two sites.

**Table 6.2: T-Test**

| Group Statistics | | | | | | |
|---|---|---|---|---|---|---|
| group Group | | N | Mean | Std. Deviation | Std. Error Mean | Sig. (2-tailed) |
| Raw RAW sales price | Sedgefield Island | 191 | 678484.71 | 551441.854 | 39900.932 | .040 |
| | Sedgefield Control Area | 154 | 837734.71 | 870290.949 | 70130.043 | .050 |
| Adjusted STANDARDISED sales price (CPI adjusted to 2012, 2012 = 100) | Sedgefield Island | 191 | 967937.27 | 671186.738 | 48565.368 | .038 |
| | Sedgefield Control Area | 154 | 1195412.10 | 1312481.689 | 105762.788 | .052 |
| raw_log10 RAW sales price (log 10) | Sedgefield Island | 191 | 5.6599 | .42188 | .03053 | .665 |
| | Sedgefield Control Area | 154 | 5.6816 | .50736 | .04088 | .671 |
| adjusted_log10 STANDARDISED sales price (CPI adjusted to 2012, 2012 = 100) (log 10) | Sedgefield Island | 191 | 5.8725 | .33260 | .02407 | .687 |
| | Sedgefield Control Area | 154 | 5.8891 | .43101 | .03473 | .695 |
| | | | | | | |



This finding was confirmed by an independent sample t-test to compare the mean as indicated in Table 6.2 of the two sites. Because parametric approaches assume that the dependent variable is measured at the ratio level, the selling prices were adjusted to CPI 2012/12 = 100 to ensure a continuous scale. There was no significant difference between the scores for the study site (M = 967937.27, SD = 671186.738 / *M* = 5.8725, *SD* = .33260) and the control site (M = 1195412.10, SD = 1312481.689 / *M* = 5.8891, *SD* = .43101); *t*(343) = -.403, p = .687 (two-tailed).

The magnitude of the differences in the mean as indicated in Table 6.1, mean difference = -.01656, 95% CI: -.09744 to .06431, was very small (eta squared = 0.002). See Annexure 6.1. According to the 5% trimmed mean score, there is no significant difference between the study area (TM = 920356.45, M = 967937.27, SE = 48565.368 / *TM = 5.8795, M = 5.8725, SE = .02407)* and the control area (TM = 1029626.55, M

= 1195412.10, SE = 105762.788 / *TM =5.9002, M = 5.8891, SE = .03473*), thus indicating that the extreme scores had no influence on the means.

The descriptive statistics, see Table 6.1, indicate that the data was not normally distributed but was negatively skewed. The study site (skewness = 1.090 / *-.328* and kurtosis = 1.114 / *-.699*) and the control area (skewness = 4.119 **/** *-.476* and kurtosis = -.483).

**Table 6.3: Tests of normality**

| Group | | Kolmogorov-Smirnov | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | | Statistic | df | Sig. | Statistic | df | Sig. |
| Raw selling price | Study site | .133 | 191 | .000 | .896 | 191 | .000 |
| | Control site | .173 | 154 | .000 | .797 | 154 | .000 |
| Adjusted selling price 2012/12 = 100 | Study site | .068 | 191 | .032 | .973 | 191 | .001 |
| | Control site | .095 | 154 | .002 | .923 | 154 | .000 |
| Transformed adjusted selling price 2012/12 = 100 | Study site | .066 | 191 | .040 | .973 | 191 | .001 |
| | Control site | .076 | 154 | .028 | .981 | 154 | .030 |
| | | | | | | | |



The skewness was confirmed by the Kolmogorov-Smirnov and Shapiro-Wilk tests for normality in which the scores were less than .05m indicating that the results were not normally distributed, Table 6.3.

The skewness in the data is also visible in the histograms in Figures 6.7 and 6.8. The skewed data can be attributed to the fact that only repeat sales over the last 20 years were used to establish if there was a trend and if there were any changes in property sales and prices after specific events.

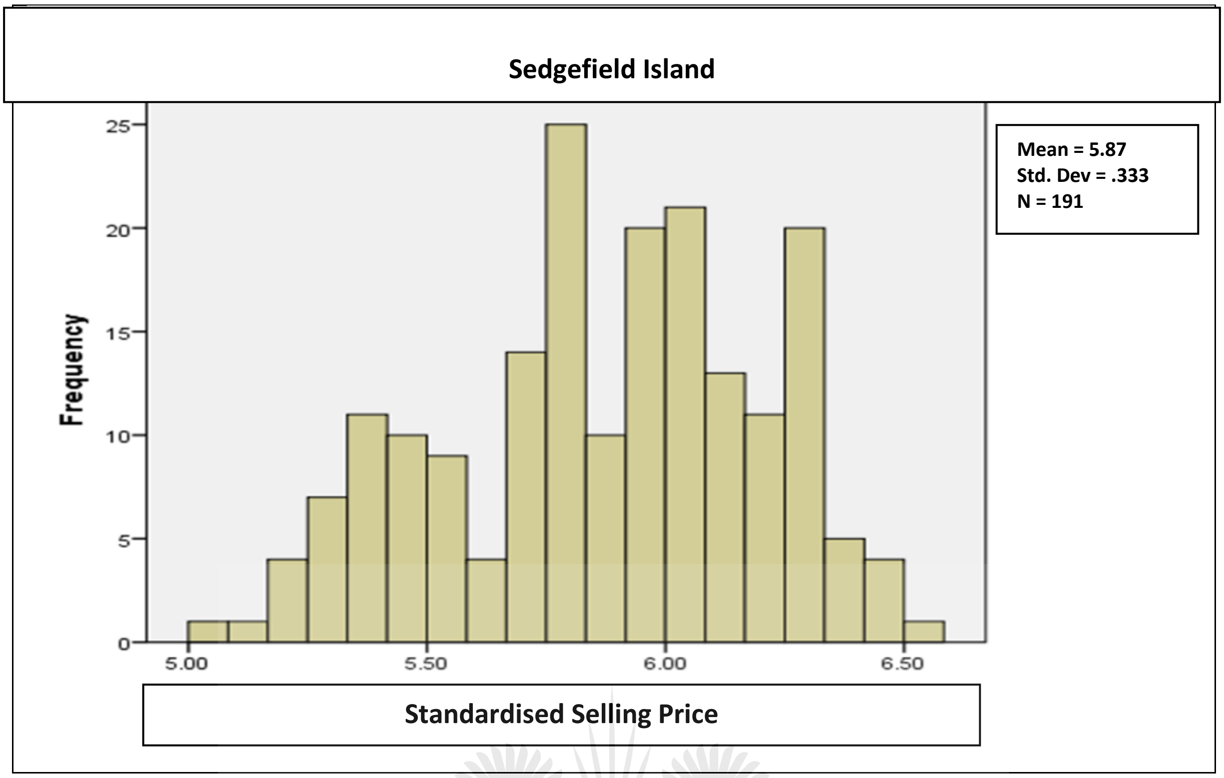


**Figure 6.7: Standardised selling price in study site (CPI adjusted to 2012, 2012 = 100, log10)**

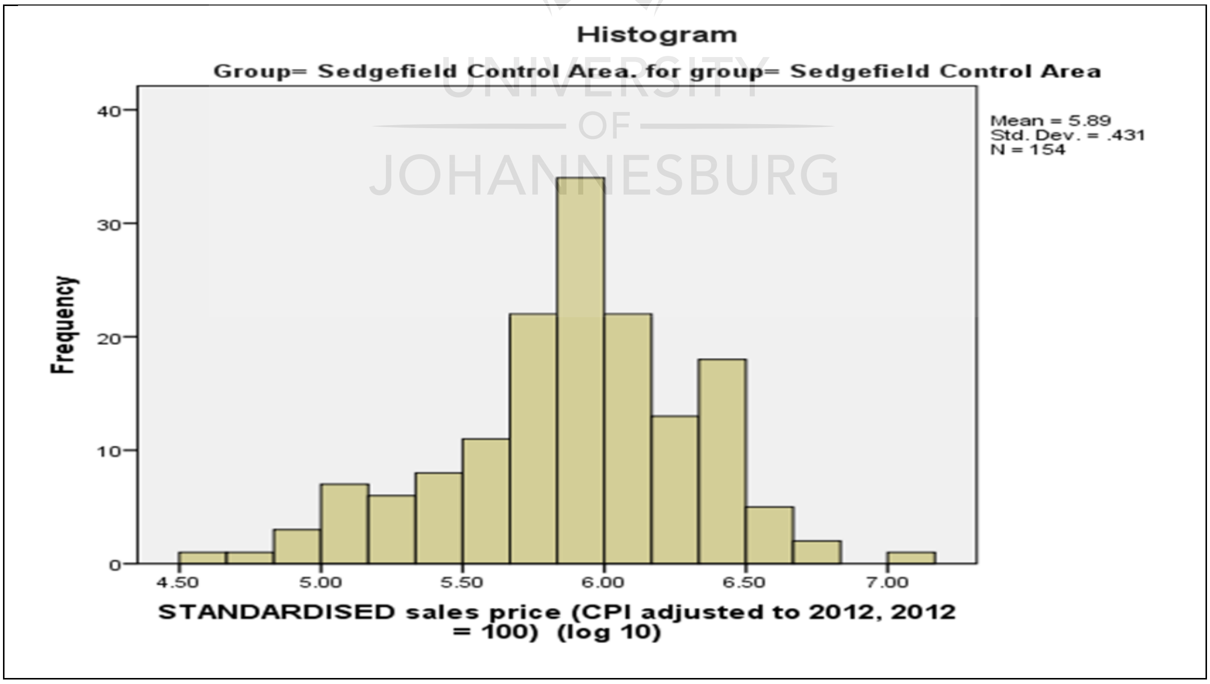


**Figure 6.8: Standardised selling price in control site (CPI adjusted to 2012, 2012 = 100, log10)**

Due to the skewness of the data, non-parametric statistical techniques were applied to test the data. The first non-parametric test conducted was the Mann-Whitney U test in which the medians of the two areas were compared. The Mann-Whitney U test revealed no significant difference in the selling prices of the study site (Md = 1 070 911.72, n = 191) and the control site (Md = 1 104 100.95, n = 154), U = 14 086.500, z = -.674, p = .500, r = 0.03. This confirmed the result of the t-test, namely that the selling prices of the two sites increased at the same rate and are thus statistically comparable. See Annexure 6.2.

A Kruskal-Wallis test was conducted to confirm that there is no statistically significant difference between the two sites. The Kruskal-Wallis test allows a researcher to compare two or more independent groups at the same time. The property sales data of the study was allocated to four different time periods in the research and control sites with approximately the same number of data points in each, namely 1990 – 1999, 2000 – 2003, 2004 – 2007 and 2008 – 2015.

The Kruskal-Wallis test for the study area revealed a statistically significant difference in selling prices across the four different groups in the study site [Group 1 (Gp1) n = 43: 1990 – 1999, Group 2 (Gp2) n = 60: 2000 – 2003, Group 3 (Gp3) n = 48: 2004 – 2007, Group 4 (Gp4) n = 40, $X^2$ (3, n = 191) = 100.199, p = .000]. The third group of selling prices ranked the highest, while the fourth group of selling prices ranked lower. The Kruskal-Wallis test for the control site revealed a statistically significant difference in selling prices across the four different groups in the control site [Gp1 n = 41: 1990 – 1999, Gp2 n = 39: 2000 – 2003, Gp3 n = 35: 2004 – 2007, Gp4 n = 39), $X^2$ (3, n = 154) = 60.513, p = .000]. Although the statistical significance was smaller at the control site than at the study site, the same trend was evident, namely that the third group ranked the highest at both sites. Selling prices peaked in 2007, the last year in the third group, and dropped sharply in 2008 because of the global economic crisis in 2008. A similar trend is evident in the line graphs that will be discussed below.

### 6.3.2 Property trends in Sedgefield (Hypothesis 3)

Having established that there was no statistically significant difference between the two sites, the study and control sites could be compared. The researcher was thus able to compare the data collected from the two sites on the selling price and dates of all repeat sales over the last 20 years to identify any trends.

Figure 6.9 indicates the trend in selling prices in Sedgefield, both study and control sites, over the last 20 years.

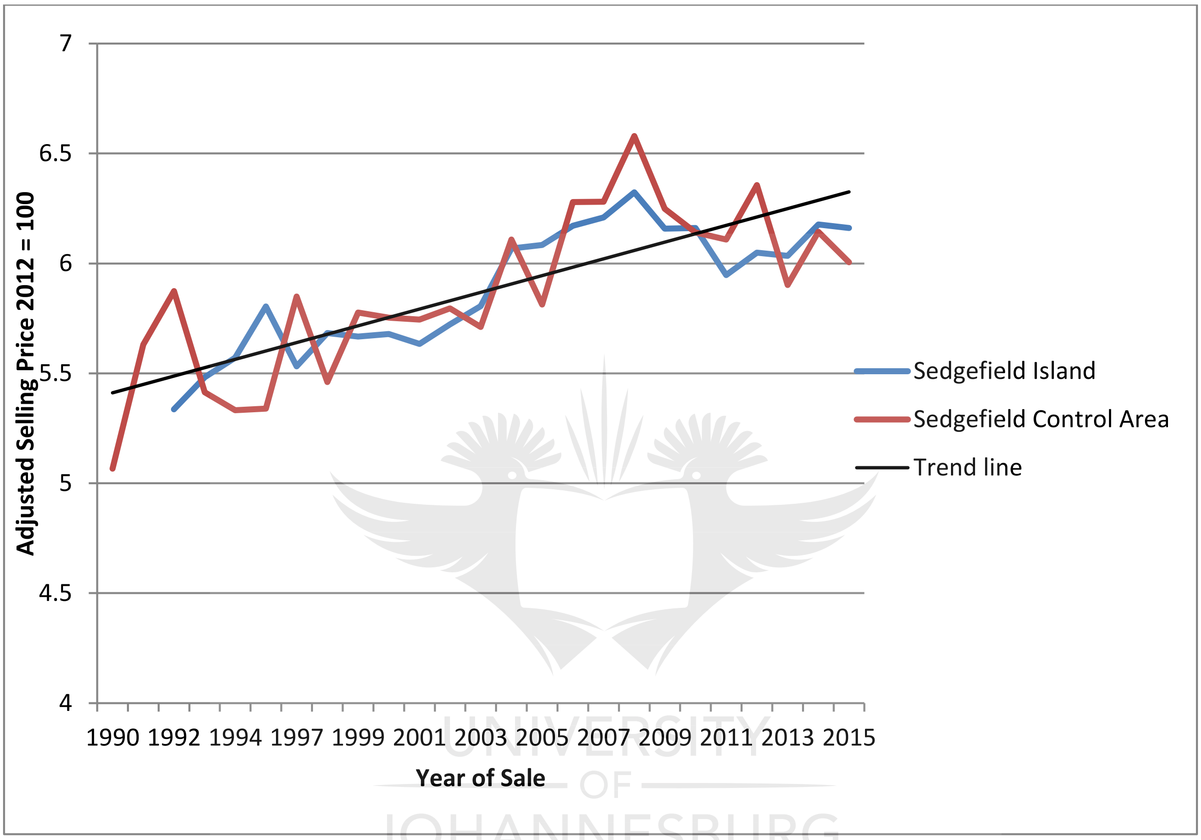


**Figure 6.9: Selling prices in Sedgefield, both study and control sites, over last 20 years**

The trend line in Figure 6.9 indicates that selling prices increased over the last 20 years for both areas. Major events that might have affected the two sites are the election of the first democratic government in South Africa in 1994, three major flooding events in 2003, 2006 and 2007 and the global economic crisis in 2008.

The results presented below suggest that flooding events had no impact on selling prices in the study area, which is prone to flooding. There was an increase in selling prices in both areas during 2003, 2006 and 2007. Even in 2007, the year in which the worst flood yet occurred in the study site (see Figure 6.4), no decline in the selling prices was evident. A similar trend was detected in the control site, which was not affected by any flooding at all. This is contrary to studies conducted by Turnbull et al. (2013), Bin, Kruse and Landry (2008), Lamond et al. (2007a & 2007b), Eves (2002) and Skantz and Strickland (1987), who found that flooding events had a negative impact on the selling prices of previously flooded residential properties.

However, the global economic crisis in 2008 did have an impact and it can be clearly seen in the decline of the selling prices between 2008 and 2009 and thereafter in both areas.

Figure 6.10 indicates the trend in the mean standardised selling prices (2012 = 100) 1990 – 2015.

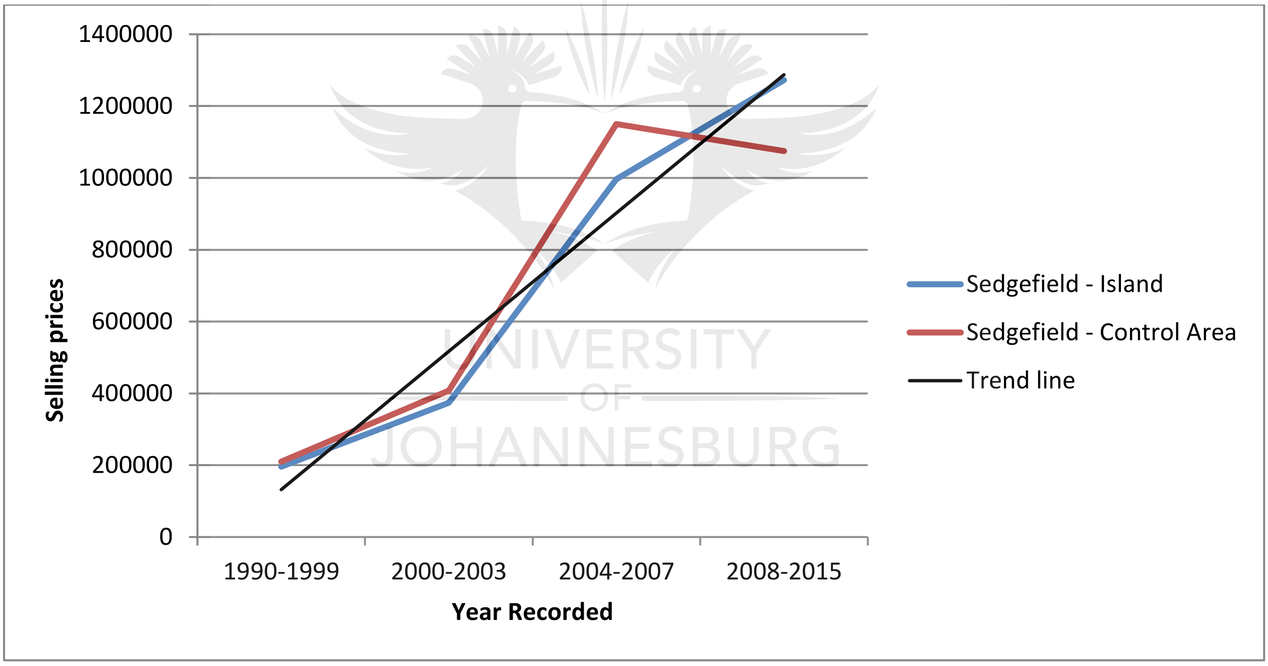


**Figure 6.10: Sedgefield mean standardised selling prices 1990 – 2015, 2012 = 100**

A similar trend was evident in the standardised selling prices, when homogeneous subsets, the four groups used in the Kruskal-Wallis test, with a harmonic mean sample size of 46.644 for the study site and a harmonic mean sample size of 38.372 for the control site, were used to compare the two sites. The researcher therefore concludes that although the selling prices where affected, the selling prices were not affected by any flooding events and that the first major negative impact was the global financial crisis in 2008.

The research thus failed to reject the null hypothesis: *There is no relationship between flood events during the past 20 years and the selling price of coastal residential property in Sedgefield*. The alternative hypothesis is therefore rejected: *There is a relationship between flood events during the past 20 years and the selling price of coastal residential property in Sedgefield*. Flood events during the past 20 years thus did not influence the selling price of coastal residential property in Sedgefield during or after flood events. This result is in contrast to the results of studies conducted by Lamond and Proverbs (2006) and Eves (2002), who found that floods did have an impact on value, although only temporarily.

### 6.3.3 Height above sea level and distance from water (Hypotheses 1 & 2)

The height amsl and the distance from the water were also investigated to determine if they influenced selling prices. It is well known that the selling price of a property is enhanced by its proximity to the water (Rouwendal, Van Marwijk & Levkovick, 2014; Rinehart & Pompe, 1999; Fraser & Spencer, 1998; Lansford & Jones, 1995) and a view of the water (McNamara, Gopalakrishnan, Smith & Murray, 2015; Hansen & Benson, 2013; Bin, Crawford, Kruse & Landry, 2008; Kriesel & Friedman, 2003; Bond, Seiler & Seiler, 2002).



The Pearson product-moment correlation coefficient, see Table 6.4 below, was used to determine whether height above mean sea level and distance from the water influenced selling prices.

**Table 6.4: Pearson product-moment correlation coefficient**

| Group | | | Raw selling price | Adjusted selling price 2012/12 = 100 | Transformed adjusted selling 2012/12 = 100 |
|---|---|---|---|---|---|
| Study area | Height above sea level | Pearson correlation | -.006 | -.051 | -.089 |
| | | Sig. (2-tailed) | .930 | .484 | .222 |
| | | N | 191 | 191 | 191 |
| | Distance from water | Pearson correlation | .023 | .013 | -.005 |
| | | Sig. (2-tailed) | .749 | .857 | .941 |
| | | N | 191 | 191 | 191 |
| Control area | Height above sea level | Pearson correlation | -.304 | -.301 | -.119 |
| | | Sig. (2-tailed) | .000 | .000 | .141 |
| | | N | 154 | 154 | 154 |
| | ` | Pearson correlation | -.366 | -.346 | -.220 |
| | | Sig. (2-tailed) | .000 | .000 | .006 |
| | | N | 154 | 154 | 154 |
| | | | | | |

The relationship between the height above sea level and distance from the water on the selling price was tested by means of the Pearson product-moment correlation coefficient. A correlation of 0 points to no relationship between the variables. In the study area a weak negative relationship was found between height above sea level and selling price, r = -.051 / -.089, n = 191, p < .484 / .222 and distance from the water and selling price, r = .013 / -.005, n = 191, p < .857 / .941. There was a slightly stronger negative relationship in the control area between height above sea level and selling price r = -.301 / -.119, n = 154, p < .000 / .141 and distance from the water and selling price, r = -.346 / -.220, n = 154, p < .000 / .006. This is an indication that the selling prices in both areas were not influenced by height above sea level and distance from the water.

The relationship between height above sea level and distance from the water on the selling prices was further investigated using Spearman's rho, see Table 6.5 below.

**Table 6.5: Spearman's rho non-parametric correlations**

| Group | | | Raw selling price | Adjusted selling price 2012/12 = 100 | Transformed adjusted selling price 2012/12 = 100 |
|---|---|---|---|---|---|
| Study area | Height above sea level | Correlation coefficient | -.009 | -.049 | -.049 |
| | | Sig. (2-tailed) | .900 | .497 | .497 |
| | | N | 191 | 191 | 191 |
| | Distance from water | Correlation coefficient | .024 | .009 | -.009 |
| | | Sig. (2-tailed) | .742 | .898 | .898 |
| | | N | 191 | 191 | 191 |
| Control area | Height above sea level | Correlation coefficient | -.118 | -.110 | -.110 |
| | | Sig. (2-tailed) | .147 | .173 | .173 |
| | | N | 154 | 154 | 154 |
| | | Correlation coefficient | -.255 | -.267 | -.267 |
| | | Sig. (2-tailed) | .001 | .001 | .001 |
| | | N | 154 | 154 | 154 |

In the Spearman's rho a correlation of 0 points to no relationship between the variables. At the study site a weak negative relationship was found between height above sea level and selling price, $r = -.049$ / $-.049$, $n = 191$, $p < .497$ / $.497$, and distance from the water and selling price, $r = -.009$ / $-.009$, $n = 191$, $p < .898$ / $.898$. A slightly stronger negative relationship was found in the control area between height above sea level and selling price $r = -.110$ / $-.110$, $n = 154$, $p < .173$ / $.173$, and distance from the water and selling price, r = -.267 / -.267, n = 154, p < .001 / .001. The selling prices in both areas were not influenced by height above sea level and distance from the water.

With regard to height amsl, the null hypothesis is accepted: *There is no relationship between the height above mean sea level and the selling price of coastal residential properties in Sedgefield*. The alternative hypothesis is rejected: *There is a relationship between the height above mean sea level and the selling price of coastal residential property in Sedgefield*.

For the distance from the water, null hypothesis is accepted: *There is no relationship between distance from the high-water mark and the selling price of coastal residential properties in Sedgefield*. The alternative hypothesis is rejected: *There is a relationship between the distance from the high water mark and the selling price of coastal residential property in Sedgefield*.

## 6.4 SUMMARY

Sales data was collected from two sites within Sedgefield, namely Sedgefield Island labelled the study site and Sedgehill labelled the control site. Although in the same town, there are distinct differences between the two sites. The study site is on average not more than 5 m amsl, flat and only the properties on the edge of the lagoon have a view of the water. The majority of the properties are within walking distance of the water. The control site is on average 20 m amsl and the majority of the properties have a view of the sea, but not all the properties are within easy reach of the water's edge. The study site is prone to flooding whereas the chances of flooding in the control site are slim.

The sales data was statistically analysed and the researcher confirmed by means of an independent sample t-test and two non-parametric tests, namely the Mann-Whitney U test and a Kruskal-Wallis test, that the two sites were comparable. The non-parametric tests were conducted because the data was not normally distributed. The data were investigated to determine any trends and evidence of events that might have influenced the property market in Sedgefield. The only visible trend was a steady increase in property prices from 1990 until 2008 when the global financial crisis resulted in a sharp decline in property prices at both sites.

The height amsl and the distance from the water of all the properties included in the two datasets were examined by means of a Pearson product-moment correlation coefficient and a Spearman rho to establish if they had an influence on selling prices. The conclusion was that the selling prices were not affected by height amsl or distance from the water.

The findings in this chapter confirm the findings of the previous chapter that the property market in Sedgefield has not taken notice of the changing climate and that the negative effect of the rising sea level and its consequential risks are not reflected in the selling prices of property in Sedgefield. In the next chapter risk and the identification of properties at risk of being affected by the rising sea level will be discussed. An instrument property valuers can apply to quantify such risk will be designed and its application proposed.

# CHAPTER 7

# QUANTIFYING THE RISK INHERENT IN THE RISING SEA LEVEL

## 7.1 INTRODUCTION

In chapter 6 a sample of Sedgefield, Sedgefield Island and Sedgehill indicated that there is not a significant difference in the variance between prices of residential properties near sea level and those in the control site further away. The findings in chapter 5 indicate that the participants, i.e. property valuers practising on the southern Cape coast, are not concerned with SLRR and its consequences. In this chapter, risk to real estate and how property valuers could deal with it will be deliberated. Models that quantify risk in real estate will be examined and the application of such models to quantify SLRR will be considered. This chapter will conclude with the proposal of a model to determine the market value of coastal residential properties that are at risk of being inundated by the rising sea level.

Global warming and climate change are a reality with 2016 globally being the warmest year recorded since 1880 (NASA, 2017:1). According to NASA (2017), the sea level has risen globally by 88.2 mm since 1993. It is therefore important that property valuers consider the SLRR when they develop opinions of value for coastal residential real estate.

## 7.2 RISK AND UNCERTAINTY

According to Adair and Hutchison (2005), the market value of real estate is affected by present-day and future uncertainties. French (2007) purports that uncertainties are present when property valuers develop an opinion of value. Adair and Hutchison (2005:254) emphasise that *'risk and uncertainty is inherent in the valuation process*'.

Byrne (2014:8) defines uncertainty as '*anything that is not known about the outcome of a venture at the time when the decision is made*' and risk as '*the measurement of a loss identified as a possible outcome of the decision*'. Adair and Hutchison (2005:255) explain that uncertainty is created by a *'lack of knowledge and information'* and in addition risk is '*when alternative outcomes and their probabilities are known*'.

According to Al-Marwani (2014), risk is an element present in any investment in real estate. Hornby (2010) defines risk as '*the possibility of something bad happening at some time in the future'*. The South African Department of Environmental Affairs and Tourism (2006) suggests that risk is a situation with an uncertain outcome. This is similar to Wight and Ghyoot's claim (2005:137) that since the real estate environment changes over time, it results in '*environmental (location) risk'*. They further suggest that due to environmental risk's connection to a specific location, it is unmanageable and can have a substantial impact on an investment in real estate. The importance of location is also emphasised by Frew and Wilson (2002:1), who maintain that '*location has always been an important determinant of a property's value*'. Zabel (2004) suggests that the value of real estate is influenced by the immobility of its location. Nitsch (2006) submits that if prime locations are chosen, the risk in real estate investments can be reduced.

## 7.3 INFLUENCE OF THE ENVIRONMENT ON PROPERTY VALUE

Researchers have studied the influence of the environment on the value of real estate. Amrusch (2007) states that the environment in which the property is located influences the price a purchaser is willing to pay for a particular property. This confirms the views of Chesire and Sheppard (1995), Freeman (1979) and Rosen (1974) that the location and environment of residential real estate influence its value. Kauko, Goetgeluk, Straub and Priemus (2003) say that the potential attractiveness of a particular erf is influenced by both the positive and negative influence of environmental externalities to the erf. Kauko et al. (2003) found that the net effect of development restrictions, due to environmental externalities, on a specific erf could range from +21.5 to – 14.5%.

Research concerning location and environmental influences on value can be broadly divided into two categories: environmental aspects that add value and environmental aspects that decrease value.

### 7.3.1 Value-adding environmental aspects

Value-adding environmental aspects such as an appealing view and proximity to water have been researched by Hansen and Benson (2013), Hindsley, Hamilton and Morgan (2013), Morgan and Hamilton (2011), Jim and Chen (2009), Bin, Crawford, Kruse and Landry (2008), Samarasinghe and Sharp (2008), Bourassa, Hoesli and Sun (2005) and Benson, Hansen, Schwartz and Smersh (1998), among others.

According to Hansen and Benson (2013), water views increase the selling price of single-family houses considerably. They conducted a content analysis of research articles, covering 25 years, in which the value of a view was researched. They concluded that the selling price of houses with a '*world class water view*' were 45 to 70% higher than houses without a view (Hansen & Benson, 2013:81).

Jim and Chen (2009:226) established that purchasers are willing to pay a premium for a house with an '*attractive view*'. Using a hedonic pricing model, they researched the value of an attractive view on private housing in Hong Kong. They established that an ocean view increased the value of residential real estate while mountain views attracted lower prices.

Hindsley et al. (2012) included Light Detection and Ranging (LIDAR) data and geographic information system (GIS) techniques in the hedonic pricing model they applied. They found that a marginal view could contribute up to 49% to the selling price of an average house with a coastal view.

Applying a hedonic pricing model, Morgan and Hamilton (2011) concluded that 40% of the average selling price of coastal property could be ascribed to an ocean view. Bin et al. (2008:446), using a hedonic pricing model, established that purchasers were willing to pay 0.3% per degree for a view, which approximates to 54% of the selling price of houses with a '*180 degree water view'*. They also established that the selling price of houses situated in SFHAs decreased by 11%.

### 7.3.2 Value-decreasing environmental aspects

Bélanger and Bourdeau-Brien (2016) observed in their study that the value of houses located inside flood zones was 2% lower than that of houses outside of the flood zone. They purported that an econometric model would have been more appropriate for their study because they had to abandon the standard hedonic price modelling due to the difficulty of obtaining individual property characteristics when they expanded the geographic coverage of their study (Bélanger & Bourdeau-Brien, 2016).

Lamond et al. (2009) and Hallstrom and Smith (2005) used repeat sales to determine the effect of flooding on house prices. Lamond et al. (2009) established that flooding temporarily reduced the value of affected properties in the UK. They also noticed that the value recovered within three years (Lamond et al., 2009).

In the US Hallstrom and Smith (2005) used a repeat sales model, which they cross-checked with a hedonic pricing model, to research the market response to risk information. They estimated that Hurricane Andrew reduced the selling prices of properties located in the SFHAs by 19%. SFHAs are land situated below the 1:100-year flood line.



Eves and Brown (2002) conducted a survey of chartered surveyors and chartered real estate valuers in all flood-prone areas in England. The purpose of the survey was to ascertain and express the effect of flooding and flood damage. They concluded that:

- there is a relationship between the magnitude of a flood and reduced residential real estate values;
- chartered surveyors, insurers and financiers are better informed regarding the effect of flooding on residential real estate than residential real estate purchasers;
- the unavailability of property insurance and property finance negatively affects residential real estate values;
- flood defences have a positive impact on residential real estate markets; and
- the provisioning of flood defences is seasonal.

The results of these studies reveal that flood events and being located on a flood plain have a negative effect on the value of residential real estate. The effect of flooding is complicated as some studies found that the decrease in prices is temporary (Lamond et al., 2009; Hallstrom & Smith, 2005; Eves, 2002).

Below et al. (2015) examined the effect of erosion on the value of coastal real estate. Applying a hedonic regression model, they established that the erosion risk is capitalised into a property's value only once the risk of loss is about to happen (Below et al., 2015).

The majority of the research mentioned above applied a hedonic pricing model. According to Manson (2009), hedonic price modelling is generally suitable when there are few transactions in a market and typically for non-income-generating properties such as residential real estate. The application of hedonic modelling must be considered in terms of its reliance on property-specific characteristics. Hedonic price modelling utilises existing data to establish the inherent value of each of the characteristics of real estate to estimate a transaction price (Manson, 2009).

Du Preez and Sale (2014) argue that although hedonic price modelling can be applied to determine property values, the model needs the structural characteristics of properties to be most effective. These structural characteristics are not present on municipal valuation rolls in South Africa. A physical inspection of each property is therefore required if the hedonic pricing model is to be applied. Econometric models and repeat sales models all depend on historical data to reach a conclusion. None of these models can thus be used to ascertain and express the effect of flooding and flood damage caused by the expected rise in sea level.

At present SLRR is still only a prediction of expected consequences, as discussed in chapter 2. Although property valuers are not required to forecast the future, they have to declare any uncertainty that may affect their opinion of value (Lorenz, Trück & Lützkendorf, 2006). Even though SLRR is still uncertain, the promulgation of the ICM Act confirms that it is a risk to be considered when property valuers develop an opinion of value for coastal residential real estate.

## 7.4 RISK ASSESSMENT

The assessment of risk and uncertainty has long been at the centre of the debate regarding investment in real estate, according to Lorenz et al. (2006), Adair and Hutchison (2005), French and Gabrielli (2004) and Mallinson and French (2000). D'Alpaos and Canesi (2014) draw attention to the lack of a specific methodology to assess risk in real estate investment. They attribute this to the difference in risk assessment between financial investments and investment in real estate. Lorenz et al. (2006) contend that the assessment and reporting of risk and uncertainty in real estate is assigned to property valuers when they are employed to express an opinion of value.

According to French and Gabrielli (2004) and Adair and Hutchison (2005), uncertainty is the unknown that property valuers have to deal with. Joslin (2005) maintains that any opinion of value in real estate is uncertain until it is confirmed by the selling price in an actual transaction. Uncertainty will always be present and it is up to the property valuer to disregard it or communicate it in words or numbers (Enever & Isaac, 2002).

In contrast, French and Gabrielli (2004:485) define risk as '*the measurement of a loss identified as a possible outcome of the decision*' while Adair and Hutchison (2005:255) define risk as '*the probability that a target rate of return will not be realised*'. French and Gabrielli (2004) and Adair and Hutchison (2005) are of the opinion that risk is quantifiable.

French and Gabrielli (2004) propose the use of Monte Carlo simulation in which a probability distribution is determined by means of market rent and all risks related to yield as variables. This approach requires that property valuers collect and analyse data from comparable properties with the purpose of establishing a suitable market rent and a range of probabilities.

Adair and Hutchison (2005:262) propose the use of a risk scoring system. This system is based on a standard credit rating model developed by D&B UK Ltd and it includes four key elements:

'*(1)* *market transparency risk;*

*(2)* *investment quality risk;*

*(3)* *covenant strength risk; and*

*(4)* *depreciation and obsolescence risk*'.

In their support for Adair and Hutchison's risk scoring system, Lorenz et al. (2006:404) decided not to define risk but to rather adopt the Chicken and Posner (1999) identification and definition of the constituent elements of risk, namely '*RISK = HAZARD X EXPOSURE'.* Lorenz et al. (2006) argue that Chicken and Posner's description reflects the risk scoring system more accurately. Kron (2005:82) added another element, namely vulnerability, in his discussion of flood risk: '*flood risk is a function of the flood hazard, the exposed values and their vulnerability'.*

Flooding is an event which temporarily covers land with water due to a storm surge, a river overflowing its banks, water pushing back as a result of a blockage and the inundation of groundwater (Kron, 2005). Flood risk can therefore be defined as '*the product of a hazard and its consequences'* (Kron, 2005:85). Kron (2005) argues that if no person or his/her assets (something of value) are affected by a flooding event, no risk exists.

Both Adair and Hutchison's risk scoring system and French and Gabrielli's use of Monte Carlo simulation are aimed at the commercial real estate market and not the coastal residential real estate market. Risk as described by Kron (2005), i.e. Risk = Hazard x Exposure x Vulnerability, can be applied to at-risk coastal residential real estate as the model does not require existing market evidence to be applied.

**Risk of rising sea level**

Although SLRR is at present insignificant, the IPCC (2013) predicts that it will increase over time and will become more significant as time goes by. The South African government has acknowledged the IPCC's findings by promulgating laws and devising plans to deal with the rising sea level (South Africa, 2008).

In chapter 5, it was established that due to the current insignificant nature of SLRR, property valuers ignore these interventions. In chapter 6, the researcher determined that flood events in 2003, 2006 and 2007 did not reflect in the selling prices of properties sold after these events. These flood events had no negative influence on the value of coastal residential real estate. This also confirmed the behaviour of property valuers, i.e. that they rely on historical information from the real estate market and ignore the risk inherent in the rising sea level.

Kron (2005) points out that the analysis of a loss event, such as a flood, can provide an indication of the cost to be incurred in future losses and that a potential future loss is called risk. Kron's formula of Risk = Hazard x Exposure x Vulnerability can be explained as follows:

- Hazard refers to an event and the probability of this event occurring.
- Exposure refers to the presence of a person and/or his/her assets at the location the event is occurring.
- Vulnerability refers to the inadequate protection of the person and/or his/her assets against a hazard.

Kron (2005) claims that natural hazards are normally not a single event but appear in many different variations and at different frequencies. Therefore the quantitative model he developed to quantify flood risk must be written in an integral form.

$$R = \int_{Qa}^{\infty} C\ (Q)\ f(Q)\ dQ$$

In the equation Q represents a flood event, C the cost or loss incurred during a specific flood event, $f$(Q) the probability density function, d for discharge and a for the first flood or when losses starting to occur (Kron, 2005:86).

According to Kron (2005), Munich Re indicated in 1997 that the analytical calculation of risk is hardly ever possible owing to insufficient data. The findings in chapter 6, namely that the floods in 2003, 2006 and 2007, did not reflect in the real estate selling prices, support Munich Re's view that there is not enough data to apply a quantitative risk model for flood events.

In 2010 Umvoto Africa (2010b:i) conducted a comprehensive sea level rise and flood hazard risk assessment of the Eden District Municipality for the Western Cape provincial government. Based on the prediction that the sea level will rise approximately 0.75 m by 2050 and 2 m by 2100 (Umvoto Africa, 2010b:17), they concluded that the rising sea level will permanently inundate all land below the 1:50-year flood line and increase the vulnerability of land below the 1:100-year flood line and exposure to sea level rise induced risks.

Umvoto Africa (2010b) applied a qualitative risk model. In the model, they divided the Eden District Municipal coastline into 36 coastal zone management units (CZMUs). The coastal risk in each unit was assessed according to their exposure to coastal erosion and inundation, groundwater contamination from saltwater intrusion and extreme coastal events (storm surges, estuarine flooding and tsunamis). A disaster risk equation, Risk (R) = (Hazard (H) x Vulnerability (V))/Coping capacity (C), was used to assess the anticipated risk created by the rising sea level.

The first step in the assessment process was to conduct a desktop study in which at-risk areas were identified. Of the 36 CZMUs identified, only 4 were ranked as high-risk areas, namely Wilderness West, Wilderness East, Sedgefield-Swartvlei and Knysna. In the second step, a risk rating scale was designed. Table 7.1 presents the risk rating scale.

**Table 7.1: Risk rating scale**

| Score | Risk Rating |
|---|---|
| 0 – 1.5 | Very Low |
| 1.50 – 3 | Low |
| 3.0 – 6 | Moderate |
| 6.0 – 15 | High |
| 15.0 - 25 | Very High |

***Source:*** *Umvoto Africa (2010b)*

A risk rating scale of 1 - very low to 5 – very high was used to indicate risk. Hazard and vulnerability had only five possible scores each. However, coping capacity had five priority areas in which each could receive a score of 5; hence the score of 5 on the risk rating scale. Table 7.2 presents the qualitative risk assessment matrix.

**Table 7.2: Qualitative risk assessment**

| | | Coping Capacity (C) | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| Hazard x Vulnerability (H x V) | 1 | 1.0 | 0.5 | 0.3 | 0.3 | 0.2 |
| | 2 | 2.0 | 1.0 | 0.7 | 0.5 | 0.4 |
| | 3 | 3.0 | 1.5 | 1.0 | 0.8 | 0.6 |
| | 4 | 4.0 | 2.0 | 1.3 | 1.0 | 0.8 |
| | 5 | 5.0 | 2.5 | 1.7 | 1.3 | 1.0 |
| | 6 | 6.0 | 3.0 | 2.0 | 1.5 | 1.2 |
| | 8 | 8.0 | 4.0 | 2.7 | 2.0 | 1.6 |
| | 9 | 9.0 | 4.5 | 3.0 | 2.3 | 1.8 |
| | 10 | 10.0 | 5.0 | 3.3 | 2.5 | 2.0 |
| | 12 | 12.0 | 6.0 | 4.0 | 3.0 | 2.4 |
| | 15 | 15.0 | 7.5 | 5.0 | 3.8 | 3.0 |
| | 16 | 16.0 | 8.0 | 5.3 | 4.0 | 3.2 |
| | 20 | 20.0 | 10.0 | 6.7 | 5.0 | 4.0 |
| | 25 | 25.0 | 12.5 | 8.3 | 6.3 | 5.0 |

***Source:*** *Umvoto Africa, 2010b*

The qualitative risk assessment scores in Table 7.2 are the sum of the hazard score multiplied by the vulnerability score and divided by the score for the coping capacity. This is an indication of the importance of the ability to cope with disasters. The hazard scores were calculated by adding the probability of the hazard happening to the severity of the hazard divided by 2. The probability was based on the prediction that the sea level will increase by 2 m by 2100, a 1:100-year event, and therefore a probability score of 3 was awarded. It is predicted that extreme coastal events will increase in frequency as the sea level rises and therefore Umvoto Africa (2010b) awarded a score of 4 for extreme events.

Three types of vulnerabilities were considered, namely social, environmental and economic (Umvoto, 2010b). Due to the gradual increase in sea level rise, the impact on society, the environment and the economy will also be gradual. Table 7.2 indicates that the resilience of a community to deal with a disaster has the ability to reduce the final risk substantially. Table 7.3 provides a summary of the coastal hazard risk assessment scores and CZMUs with the highest risk rating.

**Table 7.3: Summary of CZMU hazard risk scores, highest to lowest risk**

| CZMU Code | CZMU Name | SLR Induced Erosion and Inundation | Groundwater Contamination | Extreme Events | Average Risk |
|---|---|---|---|---|---|
| K1 | Sedgefield-Swartvlei | 6.4 | 9.5 | 9.5 | 8.5 |
| G5 | Wilderness East | 8.3 | 6.5 | 9.2 | 8.0 |
| G4 | Wilderness West | 8.3 | 6.5 | 9.2 | 8.0 |
| K6 | Knysna | 6.7 | 7.5 | 9.5 | 7.9 |
| B2 | Plettenberg Bay | 5.8 | 6.7 | 9.6 | 7.4 |
| M5 | Hartenbos | 5.8 | 5.7 | 9.6 | 7.1 |
| B3 | Keurbooms-Bitou | 5.8 | 5.7 | 9.6 | 7.1 |
| B6 | Nature's Valley | 5.7 | 4.8 | 9.6 | 6.7 |
| M6 | Klein-Brakrivier | 5.8 | 5.0 | 8.6 | 6.5 |
| M7 | Groot-Brakrivier | 5.8 | 5.0 | 8.6 | 6.5 |
| K3 | Walker's Bay | 4.8 | 4.8 | 9.6 | 6.4 |
| M4 | Mossel Bay | 5.0 | 4.8 | 8.6 | 6.1 |
| B4 | Keurboomsstrand | 4.3 | 4.3 | 6.7 | 5.1 |
| M8 | Outeniquastrand | 5.0 | 3.6 | 6.7 | 5.1 |
| H4 | Stilbaai | 3.3 | 5.2 | 6.7 | 5.1 |
| K2 | Goukamma | 3.6 | 5.7 | 5.0 | 4.8 |
| M2 | Vleesbaai | 4.2 | 4.2 | 5.7 | 4.7 |
| G6 | Kleinkrantz | 4.3 | 3.6 | 5.8 | 4.6 |
| K4 | Buffelsbaai | 3.6 | 4.3 | 5.0 | 4.3 |
| G1 | Herolds Bay | 2.9 | 3.6 | 5.8 | 4.1 |
| G3 | Victoria Bay | 2.9 | 3.6 | 5.8 | 4.1 |
| H1 | Witsand | 3.3 | 2.8 | 5.8 | 4.0 |
| M1 | Visbaai | 2.9 | 4.2 | 3.8 | 3.6 |
| G2 | George | 2.4 | 5.0 | 3.0 | 3.5 |
| K7 | Noetzie | 2.4 | 3.6 | 4.2 | 3.4 |
| M3 | Pinnacle Point | 2.9 | 3.6 | 3.6 | 3.3 |
| B5 | De Vasselot | 2.9 | 3.6 | 3.6 | 3.3 |
| B7 | Bloukrans | 2.9 | 3.6 | 3.6 | 3.3 |
| H6 | Gouritsmond | 2.6 | 3.6 | 3.3 | 3.2 |
| H5 | Ystervark | 1.9 | 5.2 | 2.2 | 3.1 |
| H3 | Jongensfontein | 2.2 | 3.3 | 3.3 | 3.0 |
| B1 | Sinclair-Robberg | 2.4 | 3.0 | 3.0 | 2.8 |
| G7 | Gerickes Point | 2.4 | 2.4 | 3.3 | 2.7 |
| H2 | Duiwenhoks | 1.9 | 2.8 | 3.2 | 2.6 |
| K5 | Brenton-On-Sea | 1.9 | 3.0 | 2.4 | 2.4 |
| M9 | Maalgate | 1.9 | 2.4 | 2.4 | 2.2 |

***Source:*** *Umvoto Africa (2010b:17)*

Although Umvoto Africa (2010b) identified 11 areas with an average high risk, only four areas, i.e. Wilderness West, Wilderness East, Sedgefield-Swartvlei and Knysna, are rated high for all three hazards they identified.

The average rating of each CZMU provides a useful tool for property valuers to determine if the area within which they received an assignment is exposed to SLRR. The rating is based on a CZMU's exposure to '*SLR induced erosion and inundation, groundwater contamination and extreme events*' (Umvoto Africa, 2010b:17). The average rating not only draws property valuers' attention to the risk in the specific area, but also provides a qualitative opinion on the level of risk to which the area is exposed.

This table and the report are available on the internet at https://www.westerncape.gov.za/text/2010/11/eden_sea_level_rise_phase_3_risk_assessment_final_(may_2010).pdf. Property valuers are thus able to access the information and the researcher anticipates that property valuers will use this table to identify at-risk areas along the southern Cape coast. Similar information is available for other areas along the South African coastline. Being able to identify at-risk areas raises the question of how property valuers should quantify SLRR.

## 7.5 SEA LEVEL RISE RISK MODEL

Real estate investments are troubled by many uncertainties (Koubková, 2015). SLRR is a new uncertainty, which has not yet been addressed in property valuation literature.

In the current literature, researchers rely on historical data to predict what will happen in a specific real estate market in the near future. The emerging nature of climate change and the promulgation of the ICM Act to adapt to and mitigate the rising sea level raised the question as to what extent and how well-established valuation processes and procedures will be affected by the changing climate and rising sea levels.

In the model presented below, the researcher demonstrates how property valuers can address the uncertainty created by SLRR. The model consists of two parts. In the first part, the elements, which affect at-risk real estate, are identified and a qualitative rating scale is developed. The second part of the model introduces an SLRR equation property valuers can apply when they develop an opinion of value for coastal residential real estate.

Figure 7.1 is a graphic representation of the problem property valuers are faced with when they get an assignment to develop an opinion of value of at-risk coastal residential properties.

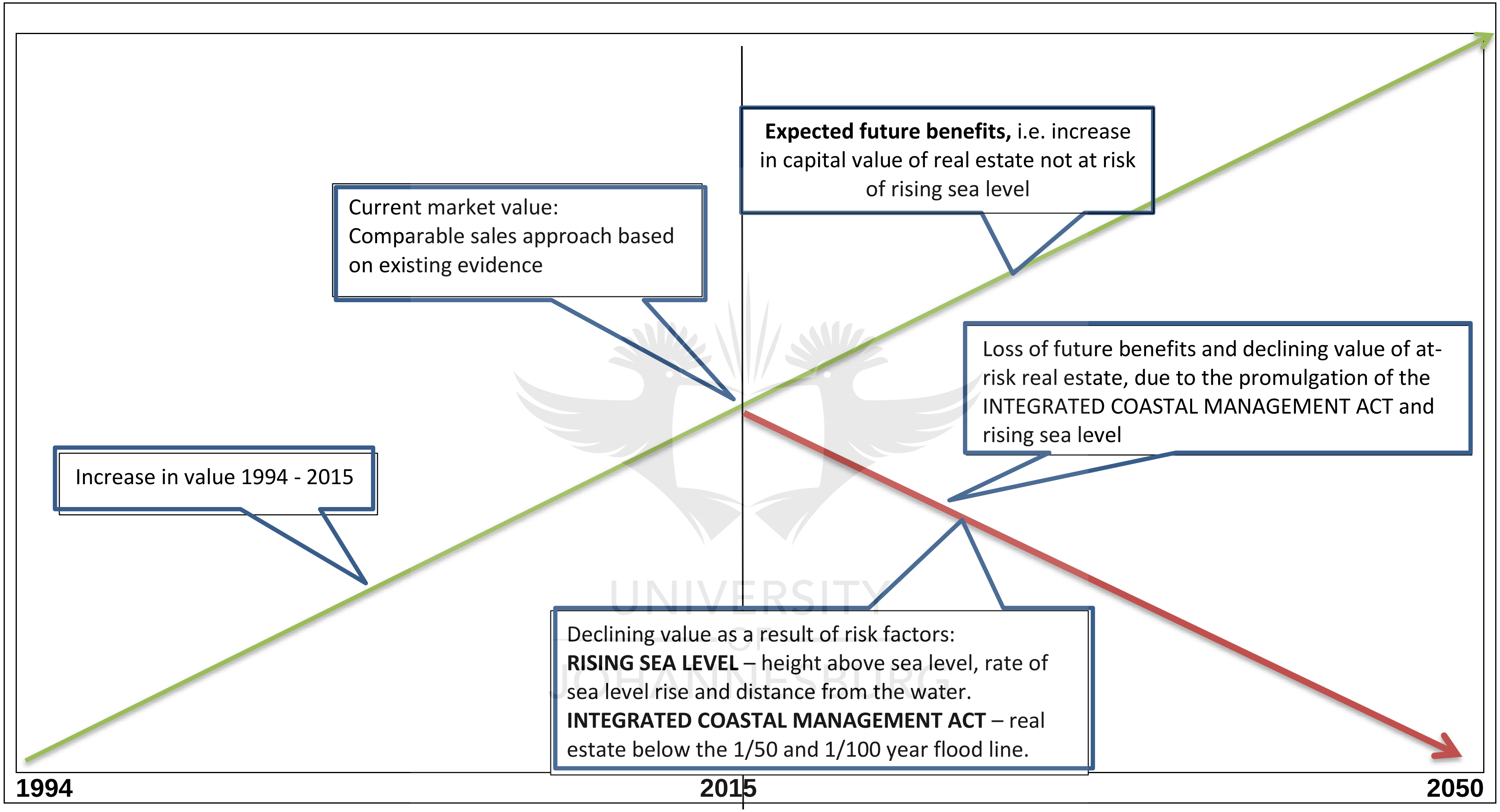


**Figure 7.1: Anticipated influence of SLRR**

Figure 7.1 illustrates the problem that SLRR will create for property valuers. The problem is that the rising sea level will diminish the future benefits of at-risk coastal residential real estate to nothing. According to Domain, Wolf and Yang (2015), residential real estate is in general the most frequently possessed asset. Du Preez, Balcilar, Razak, Kock and Gupta (2016) calculate that 29,4% of South Africans' assets are in residential real estate. The decision to invest in real estate is based on the principal of anticipation: '*value is created by the anticipation of benefits to be derived in the future*' (Appraisal Institute, 2014:27). Brown and Klingenberg (2015) state that it is the anticipation of a future return that is higher than the current value which motivates investors to invest in real estate. Although it is not yet visible in the market, the rising sea level and the promulgation of the ICM Act have changed the future expectations for at-risk properties in the coastal residential real estate market in South Africa.

The green line in the graph in Figure 7.1 indicates the increase in value of residential properties in the study area, based on repeat sales, from 1994 to 2015 and the anticipated trend into the future.

The year 2015 was randomly selected and represents the stage when the impact of the promulgation of the ICM Act should have been visible in the marketplace. Although the ICM Act was promulgated in 2008 and amended in 2014, it has not been implemented yet and this may be one of the reasons why the coastal real estate market has not responded to the SLRR (South Africa, 2014a). The Western Cape government is currently busy with the fourth phase of the implementation (Bekko, 2016).

Section 53 of the ICM Act describes the public participation process required (South Africa, 2008). During this process, the public should be made aware of the implications of the ICM Act. Among these is that properties located within the coastal protection zone, 100 m from the high-water mark and below the CML might be at risk (South Africa, 2014a).

Figure 7.2 shows the coastal protection zone and its constituent parts.

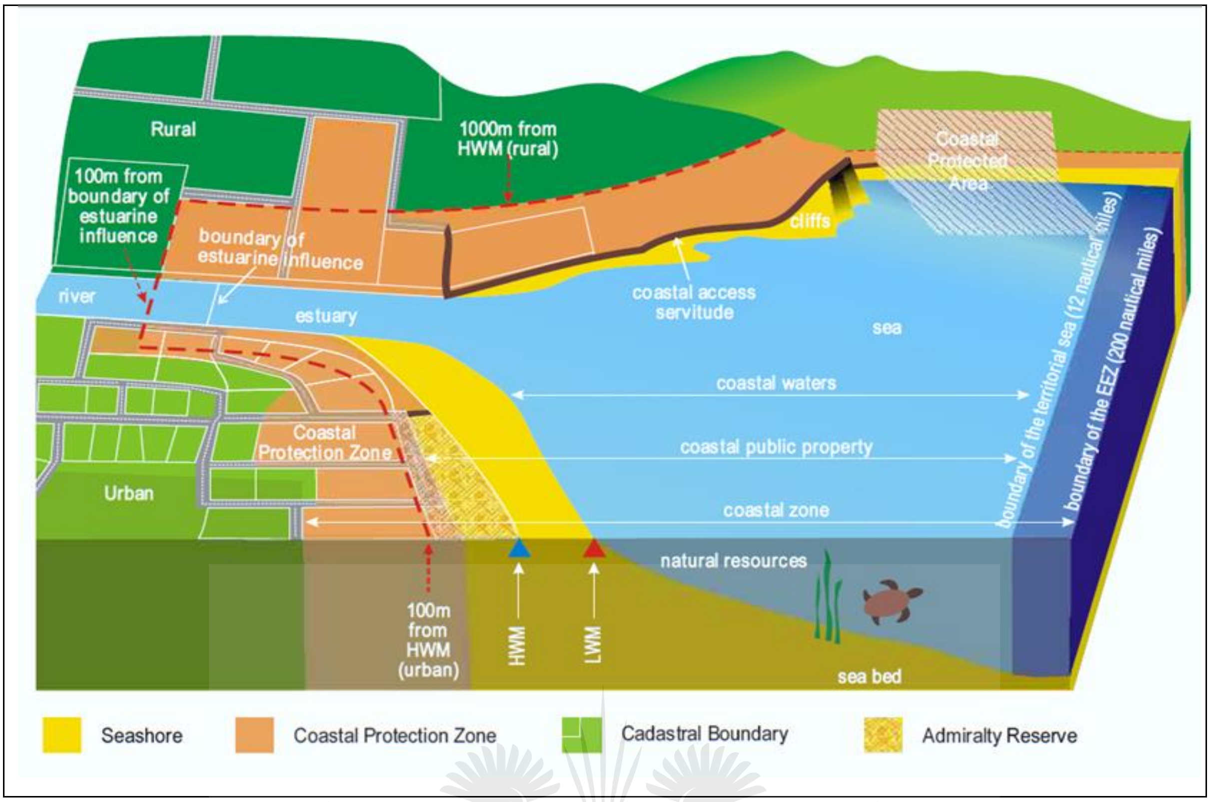


**Figure 7.2:** **Coastal zone of South Africa**

**Source:** Celliers, Breetzke, Moore & Malan (2009)

The different parts within the coastal zone along the South African coastline are indicated in Figure 7.2. The coastal protection zone reaches 100 m inland from the high-water mark in urban areas and 1 000 m inland in rural areas. The zone further includes all land that will be inundated during a 1:50-year flood, caused by a storm event (South Africa, 2009). The height amsl and the distance of a property from the high-water mark will consequently have an influence on the risk to which this property is exposed.

Section 14 of the ICM Act stipulates that if the high-water mark moves inland and remains at that point for three years, the owner loses ownership of that land and is not entitled to compensation from the state for the loss of ownership (South Africa, 2014a). The consequence of section 14 of the ICM Act is far reaching and annuls any future benefits of properties at risk of being inundated. Property valuers will therefore have to consider the height above sea level and distance from the high-water mark when they develop an opinion of value of coastal residential real estate. Although the promulgation of the ICM Act affirms the South African government's view that the rising sea level is a risk, the slow rate at which the sea level is rising weakens awareness of the risk awaiting coastal residential real estate.

In the interviews conducted with participating valuers, none of them indicated that they considered the impact of the rising sea level or the implementation of the ICM Act in their valuation of real estate. Fitchett, Grant and Hoogendoorn (2016) found similar views in a study they conducted in two small towns on the eastern Cape coast.

The examination of the sales data in chapter 6 did not provide any indication that purchasers and sellers of residential real estate in the study area were concerned about the implications of the rising sea level or the promulgation of the ICM Act.

The slow onset of the rising sea level will have to be taken into account when property valuers develop an opinion of value for coastal residential real estate. This raises the question of how property valuers should deal with SLRR.

### 7.5.1 Elements of risk of rising sea level

The three elements identified in 7.5 above, i.e. height above sea level, distance from the high-water mark and time, are incorporated in the SLRR model considered below. These elements are normally not explicitly considered in the valuation process.

#### *7.5.1.1 Height above mean sea level*

The impact of flood plain location on value has been well researched by Bélanger and Bourdeau-Brien (2016), Lamond et al. (2009) and Hallstrom and Smith (2005), among others.

The influence of the height amsl by itself has not been researched. This element is of special importance to this study area which is partly surrounded by the Swartvlei Estuary.

Due to its dynamic nature, the degrading impact of human activity and coastal development along the southern Cape coast and an absence of estuary management plans, Van Weele et al. (2015) recommend that a 5 m or 10 m amsl contour be used as the coastal management line. These contour lines match up with the 1:50-year and 1:100-year flood lines.

The probability that properties situated closer to mean sea level will be permanently inundated is greater than those situated higher up. The height amsl will therefore be one of the elements of the rising sea level that can have a negative impact on property values and should be taken into account by property investors.

#### *7.5.1.2 Distance from the water*

A number of researchers have examined the influence of the distance from the water to a water view such as Jim and Chen (2009), Bin, Crawford, Kruse and Landry (2008), Samarasinghe and Sharp (2008), Bourassa, Hoesli and Sun (2005) and Benson, Hansen, Schwartz and Smersh (1998), among others.

The requirement in the ICM Act that no development will be allowed within 100 m from the high-water mark indicates that properties situated closer to the high-water mark have a higher risk of being inundated. Properties situated close to the water and just above the current mean sea level will have a higher risk but those 5 m amsl and further than 100 m from the high-water mark will have a smaller risk. Height amsl and distance from the high-water mark should therefore be included in any risk equation.

#### *7.5.1.3 Time*

The slow rate at which the sea level is rising should also be considered. Umvoto Africa (2010b) estimated a sea level rise of 0.75 m by 2050 and 1 m by 2100 along the southern Cape coast. Umvoto Africa’s estimates are based on the IPCC’s sea level rise predictions for the 21$^{st}$ century, i.e. until 2100 (IPCC, 2013). The IPCC (2013), Lorbacher et al. (2012) and Rahmstorf (2007) established that the sea level is rising at approximately 3,2 mm per annum.

Church et al. (2008) emphasise that the higher sea levels will increase the intensity and frequency of storm surges. They postulate that the return period for storm surges will become quicker.

2050 and 2100 may seem far off but if the average period of a bond, 20 to 30 years, is taken into account, 2050 is just over 30 years away. Property valuers should therefore be attentive to the effect time will have on the remaining useful life of an at-risk property.

### 7.5.2 At-risk property value model

The aim is to quantify the at-risk value of coastal residential real estate that is exposed to the risk of rising sea level. The model is based on the framework for the valuation of environmental contamination (Jackson, 2003).

According to the Appraisal Institute (2014), there are three influences that affect the value of contaminated property, namely cost, use and risk influences. These influences are included in the following formula (Jackson, 2003:314):

*Impaired value = Unimpaired value – Cost effect – Use effect – Risk effect*



Jackson (2003) postulates that the unimpaired value is typically estimated by means of one of the traditional approaches, i.e. comparable sales, income capitalisation or cost. However, he argues that in the case of an environmental contaminated property, the traditional approaches cannot be applied and an alternative approach must be followed due to limited data and other restraining factors. He emphasises that the approach must still be grounded in appropriate market data.

When the influence of the rising sea level is considered, it is the lack of market data which produces the problem for property valuers. The environmental risk imagined by the rising sea level is based on predictions by natural scientists and the provisions of the ICM Act.

With reference to Jackson's argument, the researcher presents the following risk model:

| |
|---|
| At-risk value (ARV) = Market value (MV) x Suggested risk coefficient |

At-risk value = Market value (MV) x Suggested risk coefficient at date of valuation is represented by $f$ (MV, $X_1$, $X_2$, $X_3$) = MV x ($X_1$ + $X_2$ + $X_3$)/3

Where
$X_1$ = height above mean sea level
$X_2$ = distance from the high-water mark
$X_3$ = time (or rate of sea level rise)



The researcher decided to use a linear function because the predictions made regarding the changing climate and the rising sea level are based on the results of linear models (Knutti & Rugenstein, 2015; Vermeer & Rahmstorf, 2009).

The purpose of the model is to determine the at-risk value of a coastal residential property. To accomplish this, the property valuer will start by determining the market value of the subject property according to the market approach as defined by the IVSs. The market approach '*provides an indication of value by comparing the subject asset with identical or similar assets for which price information is available*' (IVSC, 2013:5).

A property valuer will be able to collect relevant market data of similar properties which sold recently to develop an opinion of value for the subject property without the SLRR. This is in line with the current practice of the property valuers in the study area as reported in chapters 5 and 6. The next step would be to quantify the risk and deduct it from the market value.

The three predicted negative influences which constitute SLRR are height above sea level, distance to the high-water mark and time. The arithmetic mean of these influences will be employed as the risk coefficient.

The tables below provide a reference from which property valuers can identify the risk factor and the value attached to the risk factor at a specific level or time. Table 7.4 indicates the probability of the subject property being flooded in relationship to its height above mean sea level.

**Table 7.4: Probability of inundation risk**

| **Height above mean sea level** | **1:50-years** | | **1:100-years** | |
|---|---|---|---|---|
| | ***%*** | ***Risk factor*** | ***%*** | ***Risk factor*** |
| **0 m** | 100 | 1 | 100 | 1 |
| **1 m** | 80 | 0.80 | 99 | 0.99 |
| **2 m** | 60 | 0.60 | 98 | 0.98 |
| **3 m** | 40 | 0.40 | 97 | 0.97 |
| **4 m** | 20 | 0.20 | 96 | 0.96 |
| **5 m** | 1 | 0.01 | 95 | 0.95 |
| **6 m** | | | 94 | 0.94 |
| **7 m** | | | 93 | 0.93 |
| **8 m** | | | 92 | 0.92 |
| **9 m** | | | 91 | 0.91 |
| **10 m** | | | 90 | 0.90 |

*Height above mean sea level*

Table 7.4 provides the percentage as well as the risk factor which should be used in the model. The 1:50- and 1:100-year flood lines indicate the probability that a specific property will be flooded once in 50 or once in 100 years (Holmes & Dinicola, 2010; Van Weele et al., 2015). The flood lines are closely linked with the height amsl in that the 1:50-year flood line is represented by the 5 m amsl contour. The 1:100-year flood line is represented by the 10 m amsl contour. The table indicates that an at-risk property located 1 m amsl has an 80% probability of being flooded in the next 50 years. The same property has a 99% probability of being flooded in the next 100 years. The probabilities are also expressed as risk factors that will be applied in the proposed model. The broad parameters, 1:50 and 1:100 years, afford property valuers flexibility to decide on the level of risk they assume once they have familiarised themselves with the physical situation regarding the subject property. It is anticipated that property valuers will initially tend to be conservative in their estimation of the risk and apply the risk factors for a 1:100-year flood. However, as the effect of the rising sea level becomes more visible, they may use the less conservative 1:50-year flood risk.

*Distance to high-water mark*



A 1 or a 0 indicates the distance to the high-water mark. If a subject property is within 100 m or less of the high-water mark, a 1 is awarded. If it is further than 100 m, a 0 is awarded in the proposed model. The ICM Act establishes a coastal protection zone to protect property against the rising sea level (South Africa, 2008). In urban areas, the coastal protection zone includes all immovable property 100 m above the high-water mark (South Africa, 2008). Properties located within the coastal protection zone are thus at risk of being inundated due to the rising sea level.

*Time*

The IPCC predicts that the sea level is rising at approximately 3,2 mm per annum. Umvoto Africa (2010b) considered a sea level rise of 0.75 m by 2050 and 2 m by 2100.

According to the IVSC (2017:82), property valuers are responsible to identify any actual or potential environmental risks during their investigation in the valuation process. It is argued that property valuers should not only identify the risk, but also pay attention to the effect time will have on the remaining useful life of an at-risk property. Table 7.5 below provides two sets of risk factors for time, and the years remaining until expected inundation in 2050 or 2100.

**Table 7.5: Risk factor years remaining**

| Current year | Year value 0 | Years remaining until 2050 | Risk factor | Year value 0 | Years remaining until 2100 | Risk factor |
|---|---|---|---|---|---|---|
| 2015 | 2050 | 35 | 0.30 | 2100 | 85 | 0.15 |
| 2016 | 2050 | 34 | 0.32 | 2100 | 84 | 0.16 |
| 2017 | 2050 | 33 | 0.34 | 2100 | 83 | 0.17 |
| 2018 | 2050 | 32 | 0.36 | 2100 | 82 | 0.18 |
| 2019 | 2050 | 31 | 0.38 | 2100 | 81 | 0.19 |
| 2020 | 2050 | 30 | 0.40 | 2100 | 80 | 0.20 |
| 2021 | 2050 | 29 | 0.42 | 2100 | 79 | 0.21 |
| 2022 | 2050 | 28 | 0.44 | 2100 | 78 | 0.22 |
| 2023 | 2050 | 27 | 0.46 | 2100 | 77 | 0.23 |
| 2024 | 2050 | 26 | 0.48 | 2100 | 76 | 0.24 |
| 2025 | 2050 | 25 | 0.50 | 2100 | 75 | 0.25 |
| 2026 | 2050 | 24 | 0.52 | 2100 | 74 | 0.26 |
| 2027 | 2050 | 23 | 0.54 | 2100 | 73 | 0.27 |
| 2028 | 2050 | 22 | 0.56 | 2100 | 72 | 0.28 |
| 2029 | 2050 | 21 | 0.58 | 2100 | 71 | 0.29 |
| 2030 | 2050 | 20 | 0.60 | 2100 | 70 | 0.30 |
| 2031 | 2050 | 19 | 0.62 | 2100 | 69 | 0.31 |
| 2032 | 2050 | 18 | 0.64 | 2100 | 68 | 0.32 |
| 2033 | 2050 | 17 | 0.66 | 2100 | 67 | 0.33 |
| 2034 | 2050 | 16 | 0.68 | 2100 | 66 | 0.34 |
| 2035 | 2050 | 15 | 0.70 | 2100 | 65 | 0.35 |
| 2036 | 2050 | 14 | 0.72 | 2100 | 64 | 0.36 |
| 2037 | 2050 | 13 | 0.74 | 2100 | 63 | 0.37 |
| 2038 | 2050 | 12 | 0.76 | 2100 | 62 | 0.38 |
| 2039 | 2050 | 11 | 0.78 | 2100 | 61 | 0.39 |
| 2040 | 2050 | 10 | 0.80 | 2100 | 60 | 0.40 |
| 2041 | 2050 | 9 | 0.82 | 2100 | 59 | 0.41 |
| 2042 | 2050 | 8 | 0.84 | 2100 | 58 | 0.42 |
| 2043 | 2050 | 7 | 0.86 | 2100 | 57 | 0.43 |
| 2044 | 2050 | 6 | 0.88 | 2100 | 56 | 0.44 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2045 | 2050 | 5 | 0.90 | 2100 | 55 | 0.45 |
| 2046 | 2050 | 4 | 0.92 | 2100 | 54 | 0.46 |
| 2047 | 2050 | 3 | 0.94 | 2100 | 53 | 0.47 |
| 2048 | 2050 | 2 | 0.96 | 2100 | 52 | 0.48 |
| 2049 | 2050 | 1 | 0.98 | 2100 | 51 | 0.49 |
| 2050 | 2050 | 0 | 1.00 | 2100 | 50 | 0.50 |
| 2051 | | | | 2100 | 49 | 0.51 |
| 2052 | | | | 2100 | 48 | 0.52 |
| 2053 | | | | 2100 | 47 | 0.53 |
| 2054 | | | | 2100 | 46 | 0.54 |
| 2055 | | | | 2100 | 45 | 0.55 |
| 2056 | | | | 2100 | 44 | 0.56 |
| 2057 | | | | 2100 | 43 | 0.57 |
| 2058 | | | | 2100 | 42 | 0.58 |
| 2059 | | | | 2100 | 41 | 0.59 |
| 2060 | | | | 2100 | 40 | 0.60 |
| 2061 | | | | 2100 | 39 | 0.61 |
| 2062 | | | | 2100 | 38 | 0.62 |
| 2063 | | | | 2100 | 37 | 0.63 |
| 2064 | | | | 2100 | 36 | 0.64 |
| 2065 | | | | 2100 | 35 | 0.65 |
| 2066 | | | | 2100 | 34 | 0.66 |
| 2067 | | | | 2100 | 33 | 0.67 |
| 2068 | | | | 2100 | 32 | 0.68 |
| 2069 | | | | 2100 | 31 | 0.69 |
| 2070 | | | | 2100 | 30 | 0.70 |
| 2071 | | | | 2100 | 29 | 0.71 |
| 2072 | | | | 2100 | 28 | 0.72 |
| 2073 | | | | 2100 | 27 | 0.73 |
| 2074 | | | | 2100 | 26 | 0.74 |
| 2075 | | | | 2100 | 25 | 0.75 |
| 2076 | | | | 2100 | 24 | 0.76 |
| 2077 | | | | 2100 | 23 | 0.77 |
| 2078 | | | | 2100 | 22 | 0.78 |
| 2079 | | | | 2100 | 21 | 0.79 |
| 2080 | | | | 2100 | 20 | 0.80 |
| 2081 | | | | 2100 | 19 | 0.81 |
| 2082 | | | | 2100 | 18 | 0.82 |
| 2083 | | | | 2100 | 17 | 0.83 |
| 2084 | | | | 2100 | 16 | 0.84 |
| 2085 | | | | 2100 | 15 | 0.85 |
| 2086 | | | | 2100 | 14 | 0.86 |
| 2087 | | | | 2100 | 13 | 0.87 |
| 2088 | | | | 2100 | 12 | 0.88 |
| 2090 | | | | 2100 | 10 | 0.90 |
| 2091 | | | | 2100 | 9 | 0.91 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2092 | | | | 2100 | 8 | 0.92 |
| 2093 | | | | 2100 | 7 | 0.93 |
| 2094 | | | | 2100 | 6 | 0.94 |
| 2095 | | | | 2100 | 5 | 0.95 |
| 2096 | | | | 2100 | 4 | 0.96 |
| 2097 | | | | 2100 | 3 | 0.97 |
| 2098 | | | | 2100 | 2 | 0.98 |
| 2099 | | | | 2100 | 1 | 0.99 |
| 2100 | | | | 2100 | 0 | 1.00 |
| | | | | | | |

The risk factors indicated in Table 7.5 assume that an at-risk property will be permanently inundated due to the rising sea level in 2050 or 2100. The risk factor is further based on the premise that the likelihood of inundation increases as time goes by.

The first period of time to inundated risk is from 2015 until 2050 and should be used if the at-risk property being valued is expected to be inundated by 2050. The second period of time to inundated risk is from 2015 until 2100 and should be used if the at-risk property being valued is expected to be inundated by 2100. The two dates, 2050 and 2100, provide property valuers with some latitude in terms of their view regarding SLRR.



The problem caused by the SLRR is that there is currently no relevant market data that property valuers can count on to inform their opinion of value. The repeat sales data collected and analysed in the study area indicates that flooding events did not have a negative impact on property prices. The trend indicates a positive increase in property prices.

The **at-risk property value** model utilises data other than market data, namely height amsl, distance to the high-water mark and time, which are available to quantify the SLRR. The model provides an objective framework for determining the risk coefficient of selected coastal properties that are at risk of the rising sea level.

## 7.6 VALUATION FRAMEWORK FOR RISK OF RISING SEA LEVEL

Property valuers surveyed who worked along the southern Cape coast indicated that they did not consider the three potential risk factors, height above sea level, distance to the high-water mark and time, when they developed an opinion of value of at-risk properties. The aim of the **at-risk property value** model is to provide property valuers with a framework they can use to bring the three risk factors together in one risk coefficient.

The first step in the framework would be to develop an opinion of the market value of the subject property (an at-risk property) on the date of valuation based on relevant market data. The appropriate approach is the sales comparison approach. During the investigation, the property valuers should identify actual or potential environmental risks by consulting Table 7.3. The average risk as indicated in Table 7.3 provides an indication of the level of the average risk: very low, low, moderate, high or very high, and also provides secondary information the property valuer can use as a starting point to make a decision regarding the level of risk. The average risk is derived from erosion and inundation, groundwater contamination and extreme events induced by sea level rise (Umvoto Africa, 2010b).

As soon as the property valuer has established that the subject property is at risk, they can apply the proposed **at-risk property value** model to measure the impact of the rising sea level risk on the subject property.

Risk factors for height above sea level and time can be acquired from Tables 7.4 and 7.5, respectively. The risk factor for distance from the high-water mark is either 1 if it is 100 m or less from the high-water mark and 0 if it is further than 100 m from the high-water mark.

**Application of the model**

The model will typically be applied in the following scenarios:

**SCENARIO 1**: A property valuer establishes that the market value of the subject property is R1 000 000 according to the market approach. During the investigation, the property valuer finds that the subject property is at risk of being inundated in future and the risk is high, as per the average risk indicated in Table 7.3. The property valuer also confirms that the subject property is situated 1 m above sea level and within 100 m of the high-water mark. The property valuer is of the opinion that the subject property will be inundated by 2050. He/she applies the model with the information provided above:

At-risk value (ARV) = MV x Risk coefficient

The suggested risk coefficient $f$ (MV, $X_1$, $X_2$, $X_3$) = MV x ($X_1$ + $X_2$ + $X_3$)/3

For example, if the market value is R1 000 000.00 x (1 m + 100 m + 2017)/3

= R1 000 000.00 x (0.80 + 1 + 0.34)/3
= R1 000 000.00 x (2.14/3)
= R1 000 000.00 x 0.71
= R713 333.33

The at-risk value of the subject property is thus R700 000 at the date of valuation.

**SCENARIO 2**: A property valuer establishes that the market value of the subject property is R1 000 000 according to the market approach. During the investigation, the property valuer finds that there is a moderate risk that the subject property will be inundated in future, as per the average risk indicated in Table 7.3. The property valuer also confirms that the subject property is situated 2 m above sea level and 300 m from the high-water mark. The property valuer is of the opinion that the subject property will be inundated by 2050. He/she applies the model with the information provided above:

At-risk value (ARV) = MV x Risk coefficient

The suggested risk coefficient $f$ (MV, $X_1$, $X_2$, $X_3$) = MV x ($X_1$ + $X_2$ + $X_3$)/3

For example, if the market value is R1 000 000.00 x (2 m + 300 m + 2017)/3

= R1 000 000.00 x (0.60 + 0 + 0.34)/3

= R1 000 000.00 x (0.94/3)

= R1 000 000.00 x 0.31

= R313 333.33

The at-risk value of the subject property is thus R300 000 at the date of valuation.

**SCENARIO 3:** A property valuer establishes that the market value of the subject property is R1 000 000 according to the market approach. During the investigation, the property valuer finds that there is a moderate risk that the subject property will be inundated in future, as per the average risk indicated in Table 7.3. The property valuer also confirms that the subject property is situated 2 m above sea level and within 100 m of the high-water mark. The property valuer is of the opinion that the subject property will be inundated by 2100. He/she applies the model with the information provided above:

At-risk value (ARV) = MV x Risk coefficient

The suggested risk coefficient $f$ (MV, $X_1$, $X_2$, $X_3$) = MV x ($X_1$ + $X_2$ + $X_3$)/3



For example, if the market value is R1 000 000.00 x (2 m + 100 m + 2017)/3

= R1 000 000.00 x (0.60 + 1 + 0.17)/3

= R1 000 000.00 x (1.77/3)

= R1 000 000.00 x 0.59

= R590 000.00

The at-risk value of the subject property is thus R600 000 at the date of valuation.

**SCENARIO 4:** A property valuer establishes that the market value of the subject property is R1 000 000 according to the market approach. During the investigation, the property valuer finds that there is a low risk of the subject property being inundated in future, as per the average risk indicated in Table 7.3. The property valuer also confirms that the subject property is situated 2 m above sea level and 300 m from the high-water mark. The property valuer is of the opinion that the subject property will be inundated by 2100. He/she applies the model with the information provided above:

At-risk value (ARV) = MV x Risk coefficient

The suggested risk coefficient $f$ (MV, $X_1$, $X_2$, $X_3$) = MV x ($X_1$ + $X_2$ + $X_3$)/3

For example, if the market value is R1 000 000.00 x (2 m + 300 m + 2017)/3

= R1 000 000.00 x (0.60 + 0 + 0.17)/3
= R1 000 000.00 x (0.77/3)
= R1 000 000.00 x 0.26
= R256 666.67

The at-risk value of the subject property is thus R260 000 at the date of valuation.

Although these risk coefficients cannot be confirmed by relevant market data, they do provide the property valuer with an indication of the impact of SLRR on the market value of coastal residential real estate. Due to the uncertainty, the researcher recommends that the property valuer not provide a single-figure value but provide a range of values as suggested by French (2007).

## 7.7 SUMMARY

In the previous two chapters, the researcher established that property valuers practising along the southern Cape coast ignore SLRR and its consequences on the market value of coastal residential real estate. In this chapter, risk was defined and property valuers' predicament concerning risk and uncertainty in the valuation process was discussed.

The influence of the environment and specifically the influence of a property's location on the value of such property was discussed. Different models to quantify both positive and negative environmental influences on property were examined and the models to quantify SLRR argued.

The assessment of risk and uncertainty and the lack of a specific methodology to assess risk in real estate was highlighted. Kron's description of risk, i.e. Risk = Hazard x Exposure x Vulnerability, and its application in at-risk coastal residential real estate was discussed.

The chapter ended with a model property valuers can apply to quantify SLRR when they receive an instruction to develop an opinion of value for coastal residential real estate. The researcher is of the opinion that the model provides property valuers with an uncomplicated approach to identify at-risk coastal residential real estate and a possible means of expressing SLRR and uncertainty. In the next chapter, the thesis will be concluded with a discussion of the conclusions, contributions, limitations and recommendations.

# CHAPTER 8

# CONCLUSION

## 8.1 INTRODUCTION

This study was designed to investigate property valuer's lived experience of the rising sea level phenomenon and to put forward a model to assist them when valuing coastal residential real estate. The findings and results will be presented according to the research question and subquestions. The chapter will be concluded with implications, contributions, recommendations and areas for further research which emerged from this research.

## 8.2 RESEARCH QUESTION

The aim of the research was to investigate the predicted effect and ensuing risk of a rise in sea level on the behaviour of property valuers in the coastal residential real estate market of Sedgefield, South Africa. The research question, was broken down into five subquestions.



The first subquestion sought to acquire an understanding of property valuers' awareness of climate change and the consequential risk of a rise in sea level on coastal residential real estate in South Africa. The property valuers who participated in the research indicated that although they were aware of the changing climate, there were different levels of awareness. Figure 5.4 in chapter 5 illustrates the respondents' responses regarding the changing climate. The majority (ten) agreed that the changing climate would affect the southern Cape coast. Seven property valuers also agreed that the changing climate would affect how they conducted their profession while eight agreed that it would have an impact on residential property in Sedgefield. These responses indicate that the majority of the participants were of the opinion that the changing climate would have an influence on how they conducted their profession from day to day.

It is important to note that the awareness of the participants was based on personal observation and not scientific evidence. On closer examination, it became apparent that the participants anchored their decisions to past events and experiences to inform their current behaviour. One declared that climate change was something that would happen in the future and was of no concern now. The anchoring behaviour is evident in two of the property valuers responses, namely: '*at the end of the day we still have to look at what the market dictate*' and '*Yet, sales still remain the indicator of market value, the amount he should have obtained, comparable sales'* .

The second subquestion investigated how property valuers contend with the rising sea level when they develop an opinion of value in the coastal real estate market in Sedgefield, South Africa. The majority of the property valuers indicated that they rely on the decisions made by financial institutions and insurers as a proxy to anchor their opinion of value when they conducted valuations of coastal residential properties. One property valuer stated that, financial institutions '*will set more stringent loan requirements or just decline the application*' (translation). Some of the property valuers had strong opinions regarding insurer's actions: '*The value is influenced by the insurance cover or no cover'* and *'it's got to marginalise the value of the property if no-one's willing to insure it*'.

Only two property valuers pointed out that they were not concerned with the actions of financial institutions or insurers because they determined the market value of a subject property by considering the specific market and not the actions of individuals or institutions: '*you value on comparative sales that is the only real way to value is comparative sales and take into account the market'* and '*No. For me it has nothing to do with market value*'. According to the majority of the property valuers, it was business as usual in that they did not consider the changing climate. Some even commented that they would not change unless something drastic happened. Their argument is based on the premise that market value is the basis of valuation and that they still depended on comparable sales to determine market value. However, some did admit that the changing climate would be important in the future: '*Will maybe deduct an amount for the future risk involved'* and '*You will have to discount that value*'. Some of the participants made vague suggestions: '*maybe deduct an amount*', '*discount that value'*, '*discount it as if you are writing it off over twenty years.*' This affirms the latter part of the thesis statement, namely that the inhibited future benefits are not reflected in valuers' opinions of value.

The third subquestion examined how property valuers adapt to or mitigate for the anticipated rise in sea level. It was concluded that although property valuers noticed changes in the environment, they did not necessarily attribute these changes to climate change or the rising sea level. The property valuers pointed out that the risks associated with the rising sea level would only have an influence on the value of coastal residential property in the distant future. They clearly indicate that as long as they did not find evidence of SLRR in the real estate market, they would keep on ignoring the effect of climate change on value. This is illustrated by comments such as: 'at the end of the day we still have to look at what the market dictate' and 'sales still remain the indicator of market value, the amount he should have obtained, comparable sales'. Evidence shown that the property valuer's knowledge regarding the ICM Act 24 of 2008 and as amended in 2014 and the impact thereof is also limited. See Figure 5.11 in chapter 5.

Subquestion fourth endeavoured to establish if the knowledge, attitudes and behaviour of market participants was a reflection of current market behaviour in Sedgefield, South Africa. Sales data was collected from two sites within Sedgefield, Sedgefield Island labelled the study site and Sedge Hill labelled the control site. Although in the same town, there are distinct differences between the two sites. The study site is on average not more than 5 m amsl, while the control site is on average 20 m amsl. The result of the statistical analysis of the sales data and the selling prices in Sedgefield, at both sites, over the last 20 years is illustrated in Figure 6.9 in chapter 6.

The sales data from both sites was statistically analysed and the researcher confirmed by means of the Mann-Whitney U test and the Kruskal-Wallis test that the two sites were comparable. Non-parametric tests were conducted because the data was not normally distributed. The data was analysed to determine any trends and evidence of events, such as flooding, that might have influenced the real estate market in Sedgefield. The only visible trend was a steady increase in property prices from 1990 until 2008 when the global financial crisis resulted in a sharp decline in property prices at both sites. Flood events in 2003, 2006 and 2007 had no impact on the trend.

The height amsl and the distance from the water of all the properties included in the two datasets were examined by means of the Pearson product-moment correlation coefficient and the Spearman rho to establish if they had an influence on selling prices. The conclusion was that the selling prices were not affected by height amsl nor distance from the water. The quantitative results in chapter 6 confirmed the qualitative findings in chapter 5, namely that the property market in Sedgefield, South Africa has not taken notice of the changing climate and that the negative effect of the rising sea level and its consequential risks are not reflected in the selling prices of property in Sedgefield, South Africa.

The findings in subquestions 1 to 4 above led to the development and acceptance of the following hypotheses.

## 8.3 HYPOTHESES

$H_0$: *There is no relationship between property valuers' disregard of the risk of sea level rise associated with climate change and the impact it has on the value of coastal residential properties in Sedgefield, South Africa.*

$H_a$: *There is a relationship between property valuers' disregard of the risk of sea level rise associated with climate change and the impact it has on the value of coastal residential properties in Sedgefield, South Africa*.

The null hypothesis was accepted because no relationship between property valuers' disregard of the risk of sea level rise associated with climate change and the impact it has on the value of coastal residential properties in Sedgefield, South Africa were found. The alternative hypothesis was thus rejected.

The hypotheses established that the height above mean sea level, distance from the water and flood events did not affected the selling price of coastal residential properties in Sedgefield, South Africa, during the last 20 years. This confirmed the participants’ behaviour of relying on historical data when they develop an opinion of value.

## 8.4 MODEL

The last subquestion undertook to establish how property valuers can identify at-risk coastal residential real estate, ascertain the vulnerability level of at-risk real estate, quantify the risk and include climate change risk when they develop an opinion of value for coastal residential real estate. In order to achieve this the model described below was developed to assist property valuers to quantify sea-level rise risk.

| |
|---|
| At-risk value (ARV) = Market value (MV) x Suggested risk coefficient |

At-risk value = Market value (MV) x Suggested risk coefficient at date of valuation is represented by $f$ (MV, $X_1$, $X_2$, $X_3$) = MV x ($X_1$ + $X_2$ + $X_3$)/3

Where

$X_1$ = height above mean sea level

$X_2$ = distance from the high-water mark

$X_3$ = time (or rate of sea level rise)

The results of the subquestions provided the necessary evidence to answer the research question. The findings and results for subquestions 1 to 4 confirmed that property valuers do not consider the SLRR because there is no visible evidence of it yet. They therefore rely on historical data (past sales) when they develop an opinion of value since they do not have any other evidence they can count on. The proposed model provides an instrument property valuers can use to include SLRR when they develop an opinion of value.

## 8.5 RELIABILITY AND VALIDITY

The use of semi-structured interviews assists the researcher to remain neutral. However, responses might also have been influenced by the researcher's presence as the interviewees were not all evenly coherent and perceptive and at times, the researcher therefore had to explain the meaning of some of the questions. Only the researcher and the transcribers had access to the data. To ensure reliability, the transcribed interview was returned to the interviewee to confirm if he/she agreed or disagreed with the content, this was done twice in 2015 and 2017.

Different validation strategies were employed to ensure validity. The research design also correlates with triangulation. The second stage in the mixed methods approach acts as a control to check if the behaviour of the market participants (buyers and sellers) in the Sedgefield real estate market was in line with that of the valuers who interpret the behaviour of buyers and sellers to develop an opinion of value. Member checking was used to check the accuracy of the transcribed interviews. The transcription of each participant's interview together with a copy of the questionnaire was sent to them to confirm the content and accuracy of the transcription. Participants were also asked to change anything they did not agree with. Although not all the participants provided a rich and thick description, some did. The researcher declared his bias right at the beginning of the study as well as at the start of each interview. All the information received was declared, be it negative or discrepant.

The researcher provided a detailed description of the research design and methodology in chapter 4, to ensure reliability. The mixed methods research design allowed the researcher to triangulate the findings obtained from the interviews with quantitative data from the study area. The recorded and transcribed interviews are available for reanalysis if required, providing for internal reliability. As this is the first study to examine property valuers' lived experience regarding SLRR, there are no similar studies available for comparison of the findings. External reliability will therefore have to rely on the ability of another researcher to replicate the research. Replication of the research is possible as there are similar research sites along the 3 800 km coastline in South Africa.

## 8.6 LIMITATIONS

Although the research sample represents the national profile of property valuers in South Africa, the intention was never to generalise. The research was restricted to coastal residential real estate on the southern Cape coast and specifically Sedgefield, the most vulnerable town in the southern Cape. The data used in the proposed model is based on predictions, as there is no historical data available. The researcher could therefore not test the accuracy of the model. The fact that the ICM Act has not been implemented yet reduces the general awareness of the long-term implications of the rising sea level and the ICM Act.

The interpretation of the qualitative findings and the quantitative results are that of the researcher and could be subject to a different interpretation by another researcher. As the first study of this nature on SLRR in South Africa, the research lacks external validity and additional research may be required to confirm validity. The geophysical coastal-marine processes which have an influence on the demarcation of the coastal management line were not considered they fall outside the scope of this research.



## 8.7 CONTRIBUTION

This was the first study in South Africa to explore the lived experience of property valuers regarding the rising sea level. The use of the mixed methods design allowed the researcher to corroborate property valuers' stated behaviour within a specific real estate market with sales data. The research thus did not simply provide an empirical description of the specific real estate market, but attempted to overcome what Levy (2006:369) refers to as '*the positivist methodological bias*'. The results support Levy's contention that the real estate academic community should conduct research which will allow them to interpret and understand real estate markets instead of providing empirical descriptions only.

The research provides insight into the behaviour of property valuers along the southern Cape coast and confirms their dependence on historical data and their anchoring behaviour when they develop an opinion of value. The research confirms that property valuers do not consider future risk of the rising sea level. This can be said because the SLRR is not reflected in sales data.

It was also the first study to focus on the valuation of coastal residential real estate. Residential real estate represents 72% of all directly owned investment in real estate (Barnes, 2016). Thus the study contributes to local property valuation literature.

This research was the first to explore the effect of the rising sea level on the market value of coastal residential real estate in South Africa. The findings indicate that property valuers do not pay attention to the SLRR and this can have far-reaching consequences for the coastal real estate market and the South African economy.

The novelty of the research is that it is the first to provide property valuers with a model they can apply to quantify the risk of rising sea level for a specific at-risk property. The model provides property valuers with an uncomplicated approach to identify at-risk coastal residential real estate and an objective methodology to quantify SLRR and uncertainty. Estate agents, purchasers and sellers of real estate, financial institutions and local authorities can also use the model to quantify SLRR.



Local authorities acquire a large portion of their income from property rates. Property rates are based on the market value of an individual property. SLRR decreases the market value of at-risk properties. Local authorities will be able to apply the proposed model to quantify the anticipated decrease in property rates.

## 8.8 IMPLICATIONS

The research findings highlight a number of implications for property valuers, purchasers and sellers, estate agents, financial institutions and local authorities. The overdue implementation of the ICM Act in the Western Cape and the manner in which the coastal management line is drawn create uncertainty in the coastal real estate market. Theron (2016:34) argues that the CML should be drawn according to '*actual coastal processes and dynamics'* and not the seaward or estuary side of cadastral boundaries. The researcher agrees with Theron's view that drawing the CML on the seaward or estuary side of cadastral boundaries is flawed. The CML was therefore not included as a variable in the model.

The model will enable property valuers to quantify SLRR and include a considered risk coefficient in their valuation reports. Property valuers who adopt the model will be able to include a risk coefficient arrived at with clarity and certainty and avoid any bias.

The research indicates that property valuers would have to update their knowledge regarding the changing climate, the rising sea level and recently promulgated environmental legislation.

## 8.9 RECOMMENDATIONS

The recommendations emanate from the findings and results in chapters 5 and 6.

Property valuers should expand their knowledge regarding the changing climate and the rising sea level. It would also be to their advantage to keep up to date with the latest environmental legislation.

The Western Cape government and coastal local authorities should start implementing the ICM Act as soon as possible.



Property valuers should adopt the model to identify at-risk properties and calculate the risk coefficient applicable to such properties. Property valuers should use their experience and good judgement to determine a risk level for such properties.

## 8.10 FUTURE RESEARCH

Recognising that this study was an exploratory study that investigated property valuers' knowledge, behaviour and attitudes along the southern Cape coast, and in particular Sedgefield, there are without doubt improvements that can be made to the research.

- Expand the sample in the research to include all property valuers who conduct valuations along the South African coast in order to generalise the research.

- Investigate the perceptions of purchasers and sellers of risk in coastal areas.
- Combine the use of the proposed model with GIS, which might increase the accuracy and applicability of the model for local authorities.
- Examine the socio-economic impact of the ICM Act on coastal communities.
- Investigate the application of the model for types of properties other than residential real estate.
- Test the model to establish its applicability.
- Determine the impact of risk disclosure and the ICM Act on property prices.

## 8.11 CONCLUSION

The results of this research indicate that property valuers who practise on the southern Cape coast are not concerned about the future risk inherent in rising sea level. Their attitude regarding the SLRR was confirmed by the statistical market analysis of repeat sales over the last 20 years in Sedgefield. The property valuers' attitude can be attributed to two reasons: the first is a lack of knowledge regarding the changing climate and the rising sea level. The second is the absence of a valuation framework or model to address climate change and SLRR.

The researcher is of the opinion that the implementation of the ICM Act and especially the public participation process will create an awareness of the changing climate phenomenon and the risks it brings about, but should also stimulate a debate among the people affected by these risks. The proposed at-risk value model will provide property valuers and all other participants in the coastal residential real estate market with a tool to quantify, or at least attempt to quantify, the impact of the rising sea level on individual properties.

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# ANNEXURES

## ANNEXURE A

## Interview schedule

UNIVERSITY
OF
JOHANNESBURG

**"Exploring the effect of the rising sea level on the market value of immovable property in Sedgefield, South Africa" survey questionnaire**

Dear sir/ madam January 2013

This questionnaire is part of a PhD study at the University of Johannesburg. The aim of the study is to determine the knowledge, attitudes and behaviour of estate agents and property valuers in the coastal residential market in Sedgefield. This research is being conducted by André Kruger a PhD, student in the Department Of Finance and Investment Management.

The questionnaire is designed to reach an understanding of the overall awareness of property valuers and not individuals. This study is primarily concerned with the influence of climate change, specifically rising sea levels on the market value of coastal residential property. Please try to answer each question and give us your honest opinion – your views on all of these issues are important.

Your response will lead to the collection of some valuable data on the ethical standards of South African Property Valuers. If you so wish, I can supply you with an executive summary of the results once complete. Feel free to contact me should you require more information.

Your participation will be highly appreciated. Kind Regards

André Kruger

Lecturer: Property Valuation and Management

**Part A: DEMOGRAPHICS**

1. Gender

| | |
|---|---|
| Female | |
| Male | |

2. Age (in years)

| |
|---|
| |

3. Highest Academic Qualification

| | |
|---|---|
| Grade 11 or lower | |
| Grade 12 | |
| Certificate | |
| Diploma | |
| Baccalaureate Degree | |
| Post Graduate Degree | |

4. Property industry specific qualifications

| | |
|---|---|
| FET Certificate, NQF 4 | |
| HET Certificate, NQF 5 | |
| PDE (Professional Designation Examination) | |
| N Dip: Real Estate (Property Valuation) | |
| Other property related qualification | |

5. Years' registered as an Estate Agent/Property Valuer

| |
|---|
| |

6. Year's in practice in a coastal area?

| |
|---|
| |

7. Have you valued residential properties in Sedgefield?

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|---|
| Yes |
| No |

8. Have you valued residential properties in other water front locations along the Garden Route?

| | |
|---|---|
| Yes | |
| No | |

If yes, please describe the location: …………………………………………………………

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**Part B: THE CHANGING CLIMATE:**

1. Are you familiar with climate change?

| | |
|---|---|
| Yes | |
| No | |

2. Are you aware of the consequences of climate change?

| | |
|---|---|
| Yes | |
| No | |



3. Please rate the risk of the possible future consequences of climate change in your region?

| | No risk | Medium risk | High risk |
|---|---|---|---|
| Heat waves, draught, fires, water shortages | | | |
| Storms, flooding | | | |
| Spreading of diseases | | | |
| Rise in sea level, salt water intrusion | | | |
| Melting ice | | | |
| Earthquakes | | | |
| Tornadoes | | | |

4. What are your thoughts on the following statements?

| | Agree | Disagree | Do not know |
|---|---|---|---|
| The climate is changing | | | |
| Climate change will affect this region. | | | |
| Climate change will have an impact on me | | | |
| The changing climate will affect how I conduct my profession. | | | |
| The changing climate will have an impact on residential property in Sedgefield | | | |

5. Have you noticed any changes in the environment that you can contribute to climate change? Please describe the change(s) below.

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6. Is this a personal observation or based on a scientific opinion?

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|---|---|
| Personal observation | |
| Scientific opinion | |

7. If based on a scientific opinion, please provide the source(s)?

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8. Which of the following economic sectors will suffer the most as a result of the effects of climate change in your region? Please rank in terms of the worst to the least, worst being 1 and least being 8.

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|---|---|
| Agriculture | |
| Forestry | |
| Property | |
| Fisheries | |
| Health | |
| Tourism | |
| Banking | |
| Insurance | |

9. The effects of climate change on the following economic sectors will have a direct impact on your duties as a property valuer? Which economic sector will be affected the most?

| | |
|---|---|
| Agriculture | |
| Forestry | |
| Property | |
| Fisheries | |
| Health | |
| Tourism | |
| Banking | |
| Insurance | |



10. Are you aware of any concrete measures taken to adapt to or mitigate for the effects of climate change by?

| | |
|---|---|
| Government (legislation, regulations) | |
| Local Authorities (bylaws) | |
| Banks | |
| Insurers | |
| Homeowners | |
| Estate agents | |
| Property Valuers | |

11. Do you consider the changing climate when you conduct valuations of coastal residential properties?

| |
|---|
| Yes |
| No |

12. If yes, please explain how you take it into account?

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13. The rising sea level is indicated as one of the possible future consequences of climate change. Do you consider the rise in sea level when you conduct valuations of coastal residential properties?

| | |
|---|---|
| Yes | |
| No | |

14. If yes, please explain how you take it into account?

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15. In your opinion, which aspect of the rise in sea level have the greatest impact on the value of coastal residential property currently? Please rank in order of greatest impact.

| | |
|---|---|
| Increase in coastal erosion | |
| Inundation (flooding of areas) | |
| Salt water intrusion | |
| Elevated coastal ground water tables | |
| Reduced protection from storms and floods | |

**Part C: VALUATION PRACTICE AND CHANGING CLIMATE**

1. Rank in order of importance the reasons purchasers purchase a property in Sedgefield. Assign a rank of 1 to the most important reason, a rank of 2 to the second most important reason, etc. Please use each of the ranks (1, 2, 3, 4 and 5) only ONCE. What is the primary reason for buying coastal residential property? Mark only one.

| | |
|---|---|
| Holiday home | |
| Retirement home (immediate occupation as retiree) | |
| Residence (owner still working) | |
| Future retirement home (buy to let at present) | |
| Investment property (for capital appreciation only) | |

2. Please rank, in order of importance, each of the financial factors that may influence the purchase of coastal residential property?

Use each number only once.

| **Financial factors** | | **Rank** |
|---|---|---|
| 1. | Inflation | |
| 2. | Business cycle | |
| 3. | Availability of mortgage finance | |
| 4. | Per capita income | |
| 5. | Mean and median household income levels | |
| 6. | Interest rate | |
| 7. | Insurance premiums (cost of insurance) | |



4. To your knowledge, do financial institutions consider the rise in sea level in the application process for a mortgage?

| |
|---|
| Yes |
| No |

5. How do insurers' mitigate the risk of the rise in sea level?

| | |
|---|---|
| Exclude at-risk properties | |
| Cancel existing policies on at-risk properties | |
| Limit indemnity | |
| Raise risk awareness | |
| Withdraw from the market | |
| Increase premiums | |
| Developed new products | |

6. Do you as valuer take the actions of financial institutions and insurers into account when you conduct a valuation of an at-risk property?

| | |
|---|---|
| Yes | |
| No | |

7. If yes, please explain how you take it into account?

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5. To what extent are the physical characteristics pertaining to a site considered by purchasers when they consider purchasing a property in Sedgefield.



Use each number only once.

| **Physical characteristics of property** | | **Rank** |
|---|---|---|
| 1. | Size and shape | |
| 2. | Corner influence | |
| 3. | Plottage (potential to combine two sites into one) | |
| 4. | Topography | |
| 5. | Utilities | |
| 6. | Site improvements | |
| 7. | Accessibility | |
| 8. | Environment | |

6. To what extent is potential home owners attracted to properties in Sedgefield. Please rank, in order of importance, the environmental influences on purchaser's decision making.

Use each number only once.

| **Environmental aspects** | | **To no extent** | **To a small extent** | **To a moderate extent** | **To a large extent** |
|---|---|---|---|---|---|
| 1. | Local climate | | | | |
| 2. | Water supply | | | | |
| 3. | Pattern of drainage | | | | |
| 4. | Quality of air | | | | |
| 5. | Presence of wildlife habitats | | | | |
| 6. | Proximity to earthquake, flood and environmental hazards | | | | |
| 7. | Proximity to streams, wetlands, rivers, lakes or ocean | | | | |

7. Please rank, in order of importance, each of the Act's that can affect property in Sedgefield.

Use each number only once.

| **Legislation** | | **Rank** |
|---|---|---|
| 1. | Deeds Registries Act 47 of 1937 | |
| 2. | Expropriation Act 63 of 1975 | |
| 3. | Physical Planning Act 125 of 1991 | |
| 4. | Restitution of Land Rights Act 22 of 1994 | |
| 5. | Development Facilitation Act 67 of 1995 | |
| 6. | Communal Property Associations Act 28 of 1996 | |
| 7. | Constitution of the Republic of South Africa 108 of 1996 | |
| 8. | Housing Consumers Protection Measures Act 95 of 1998 | |
| 9. | National Environmental Management Act 107 of 1998 | |
| 10. | National Heritage Resources Act 25 of 1999 | |
| 11. | National Environmental Management: Integrated Coastal Management Act 24 of 2008 | |

8. How important is the following externalities from the perspective of a purchaser at the date of purchase? Please indicate your answer using the following 4-point scale where

1 = totally unimportant

2 = unimportant

3 = important

4 = very important

| | Totally unimportant | Unimportant | Important | Very Important |
|---|---|---|---|---|
| Municipal service, roads and bridges | | | | |
| Dumping (garden and building rubble) | | | | |
| Availability of finance | | | | |
| National fiscal policy (capital gains tax) | | | | |
| Cost of services (local authority) | | | | |
| Reliability of electricity and water supply | | | | |
| Availability and cost of insurance | | | | |
| Business cycle | | | | |
| Bylaws | | | | |



9. Do you agree or disagree with the following statement? The expected rise in sea level has changed the basis of valuation valuers used to determine the market value of coastal residential property.

| | |
|---|---|
| Agree | |
| Disagree | |

10. Please provide reasons for your answer above?

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11. Please explain how you would conduct the valuation of the following property:

The subject property is situated on Sedgefield Island a suburb of Sedgefield, on the Swartvlei estuary. It is one metre above sea level, the sea is rising at a rate of fifty millimetres per annum, and thus the property will probably be below sea level in 20 years' time.

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12. Have you considered using (rising) insurance premiums as a proxy of the risk created by the rising sea level when conducting valuations of at-risk properties?

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| Yes | |
| No | |



13. If yes, please explain how you would make use of insurance premiums as a proxy of the risk created by the rising sea level.

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14. Have you considered using multiple regression and hedonic pricing models when conducting valuations of at-risk properties?

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|---|---|
| Yes | |
| No | |

15. If yes, please explain how you would use multiple regression and hedonic pricing models when conducting valuations of at-risk properties.

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16. Have you considered using experts' views and proxies to calculate the impact on real estate related variables when conduction valuations of at-risk properties?



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|---|---|
| Yes | |
| No | |

17. If yes, please explain how you would use experts' views and proxies to calculate the impact on real estate related variables when conduction valuations of at-risk properties.

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**Part D: VALUERS ATTITUDE TOWARDS THE CHANGING CLIMATE**

1. Are you aware of any climatic conditions that will affect this area in the future?

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2. How will this climatic condition affect coastal residential property in the area?

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3. To what extent will the possibility of flood damage due to climate change impact on the future value of coastal residential properties in Sedgefield?

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4. Why should this be taken into account when the market value of coastal residential property is determined? Please motivate your answer.

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5. Should the current valuation approaches be adjusted to incorporate the possibility of climate change and specifically a rise in sea level?

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|---|---|
| Yes | |
| No | |

6. If yes, what changes should be in current valuation approaches to incorporate the possibility of a rise in sea level.

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Thank you for taking time to conduct this interview.

## ANNEXURE B

# The influence of climate change on the market value of coastal residential property in South Africa

André Kruger
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## Abstract

The emerging nature of climate change and events associated with climate change raises the question of to what extent and how the changing climate will affect the well-established property valuation processes and procedures. Events like the one in March 2007, when the KwaZulu-Natal coast was hit by storm swells which severely damaged coastal properties, is a typical example. The economic loss was estimated to be more than one billion rand. Risk associated with the changing climate is on the increase and if the number of studies (nationally and globally) regarding this phenomenon is taken into account there is a need to quantify this risk. In these national and global studies a variety of concepts, not related to market value or a manipulated form of market value, is used to quantify economic loss. However, financial decisions regarding property, plant and equipment are made based on the concept of market value (market value = fair value). This raises the question; this study will attempt to answer. How should property valuers change their current practice of investigating past market behaviour to arrive at an opinion of market value to also include climate change risk? This study aims to identify the knowledge, perceptions and practices of property valuers in a particular property market, on the Southern Cape coast, South Africa regarding the predicted rise in sea level. The researcher will attempt to construct an instrument property valuer's can use to determine the market value of coastal residential properties. The Southern Cape coast was chosen because it was identified in two separate studies conducted in 1993 and 2010 as the stretch of coastline along the South African coast most vulnerable to a rise in sea level.

*Keywords: climate change, rising sea level, market value, residential property, coastal property, risk, immovable property*

## 1 Introduction

Property valuers evaluate past market behaviour, to develop an opinion of market value Armitage [1]. Events like Hurricane Katrina, which hit New Orleans, USA in 2005 and the storm swell on the KwaZulu-Natal coast, South Africa in March 2007 can severely damage coastal properties. The damage caused by the KwaZulu-Natal storm swell was estimated to be more than one billion rand Smith et al [2]. In 1992, Hughes conducted a study in which the impact of sea level rise on the South African coastal environment was researched Hughes [3]. In the study he found that the Southern Cape coast was vulnerable to storm events similar to the storm swell on the KwaZulu-Natal coast in March 2007 Hughes [3]. He also pinpointed Knysna and Sedgefield as the most likely places for similar storm events to occur Hughes [3]. Hughes's findings were confirmed by several South African studies such as Smith et al [2], Cartwright [4], Brundrit [5], Blake [6], Blake and Chimboza [7] and Blake [8].

A temporary decline in selling prices after storms and the unpredictability of such events create a problem for property valuers who rely on historic data and economic trends to estimate the market value of immovable property Beracha [9]. This is further complicated by the reality that the impact of climate change is modelled on what might happen in the future, either in the short or long-term. In response to climate change the South African Government has promulgated the National Environmental Management: Integrated Coastal Management Act No 24 of 2008. The purpose of the Act is to mitigate the potential impact of a rise in sea level along the South African coast South Africa [10]. This legislation compels provinces and local authorities to delineated coastal set-back lines to support improved planning and management of vulnerable coastal areas South Africa [10]. Currently provinces and local authorities are busy with the delineation process and it is thus difficult to estimate the cost of these mitigating measures. Property valuers therefore cannot rely on past market behaviour regarding climate change to provide a necessary perspective for the future. The slow onset nature of climate change thus raises the question, to what extent and how the well-established valuation processes and procedures will be affected by climate change.

Although much research has been done on climate change and the impact thereof on the environment, very little research has been done regarding the effect of climate change on the market value of immovable property. Research on the effect of climate change within the property valuation community is directed at sustainability issues De Francesco [11], Lutzkendorf [12], Austin [13] and Warren-Myers [14] amongst others. Only one study was found that commented on the effect of climate change on the market value of coastal residential property Bienert et al [15]. However, within other disciplines there are several studies in which an attempt was made to quantify the potential risk of climate change to immovable property in monetary terms. In two of these studies Henneke et al [16] and Cartwright [4], the value of land was based on the average value for land in an entire suburb and no distinction was made with regard to the location of such properties, for example sea front or inland properties . This is contrary to valuation theory and standard valuation practice.

*Models to Evaluate the Quantitative Effects of Climate Change on Real Estate Markets* is the first study in which researchers drew a direct link between climate change and the predicted effect thereof on the market value of immovable property Bienert et al [15]. They clearly stated that "… today's value of land is always the current value of future profit potentials which can result thereof. If this future profit is restricted due to climate change, it has to be considered in today's value." Bienert et al [15]. Although Bienert et al [15] drew the valuation fraternities' attention to the impact of climate change on the market value of immovable property no follow up studies were conducted.

**2 PROBLEM STATEMENT**

"The economic concept of value is not inherent in the commodity…" but "… is created in the minds of individuals who make up the market." according to the Appraisal of Real Estate [17]. Property valuers are employed to interpret and analyse the property market in an attempt to estimate and develop an opinion of the market value of fixed property Betts and Ely [18]. Property valuers rely on information from the past to arrive at an opinion of value at the date of valuation. According to Ratcliff "… only recent transactions can be used in the analysis of recent market behaviour, and the forecast is as of today or the near future." Ratcliff [19]. He expands his observation when he refers to valuation instructions that call for long-range future perspectives, "These long-range forecasts require a long-range market analysis that evaluates past market behaviour over a long enough history to provide the necessary perspective for prophecy" Ratcliff [19].

Due to the slow onset nature of climate change there are no past market behaviour on which property valuers can base their market analysis. This raises the question of how and to what extent climate change, specifically rising sea levels, will affect the well-established valuation processes and procedures. Measuring the impact of climate change relies on predictions of what might happen in the future, either in the short or long-term. Property valuers can therefore not rely on the past to provide the necessary perspective for prophecy referred to by Ratcliff [19] when they deal with a rise in sea level. Another impediment is raised by Bienert et al [15] when they state that a restriction of future profits must be considered in today's value.

The problem is that property valuers will have to take the extent of the detrimental effect and associated risks of the rising sea level into account when they receive an instruction to determine the market value of coastal residential properties. At present property valuers do not have a basis to determine the risk of long-term changes like a rise in sea level on an investment in coastal residential properties.

## 3 Research Question

The aim of the research is to investigate the behaviour of property valuers in the coastal residential market of Sedgefield with regard to the predicted effect and ensuing risk of a rise in sea level in their valuations. In order to acquire an understanding of how property valuers deal with climate change risk in practice.

Getting a better understanding of how property valuers respond to the emerging nature of climate change will be an important insight in understanding the property market of the future in Sedgefield. In order to achieve the aim, answers will be pursued by asking the following research question and objectives.

The central question that will guide the research is: To what extent does the predicted rise in sea level and ensuing risk thereof affect property valuer's behaviour in the coastal residential market in Sedgefield and how will this influence valuation practices in South Africa?

The following objectives will be pursued:

a. To establish the knowledge and attitudes towards the consequential risk of a rise in sea level on property valuers practicing in Sedgefield's property market;
b. To ascertain if and how property valuers use their knowledge of the rising sea level when they explore the property market in Sedgefield;
c. To investigate the behaviour of property valuers in their adaption and mitigation for the anticipated rise in sea level; and

d. To use sales data from the property market in Sedgefield to establish if the knowledge, attitudes and behaviour of property valuers are reflected in current market behaviour.

# 4 Literature Review

The emerging nature of climate change raises the question of how and to what extent climate change will affect valuation theory. According to Kummerow [20] valuation theory consist of four components: "1) Value equals discounted expected future benefits of ownership; 2) Value is proportional to expected utility of various property characteristics; 3) Prices are revealed in market transactions; and 4) Prices tend to adjust towards equilibrium where supply and demand would be in balance and prices unchanging, but this process takes time and markets are normally not at equilibrium" Kummerow [20].

Property valuers therefore look at past market behaviour, to develop an opinion of market value. Measuring the impact of climate change relies on predictions of what might happen in the future, either in the short or long-term. Consequently property valuers cannot rely on past market behaviour regarding climate change to provide the necessary perspective for prophecy referred to by Ratcliff [19]. According to Rudman [21] the changing climate is a reality that may have far reaching social, economic and environmental consequences. A result of the predicted increase in temperature of between 4° – 6,4° C by 2099 will be visible in changing weather and precipitation patterns as well as a rise in sea level of 0.59 m Nicholls et al [22].

The rise in sea level is the result of a thermal expansion of the oceans, melting of the ice caps and glaciers and an increase in the ice discharge from the ice sheets in Greenland and Antarctica Nicholls et al [22]. The IPCC's predictions of sea level rise were confirmed by a study of the South African tide gauge records over the past 30 years Theron and Rossouw [23]. Theron and Rossouw's [23] study confirmed the findings of an earlier study conducted by Hughes [3] in which he found that the predicted rise in sea level will be accompanied by beach erosion, flooding and inundation, salt water intrusion and elevated coastal groundwater tables and storm damage .

In two South African coastal risk assessment studies an attempt was made to establish the impact of a rise in sea level and the associated hazards on the local economy. The first was a study conducted by Anton Cartwright in 2008 for the City of Cape Town with the primary aim "To model and understand the ramifications of predicted sea-level rise and increased storm events for the City of Cape Town, thereby providing information that may be used for future planning, preparedness and risk mitigation" Cartwright [4]. In the study he refers to the diverse group of people and institutions who will be influenced by a rise in the sea-level and the distinctly different values they will place on the affected goods and services.

For example the owners of immovable property would like to know what it will cost to replace equipment and property lost in a sea-level rise event Cartwright [4]. Cartwright explains that this is a common mistake often made in environmental risk analysis when replacement cost is equated to economic loss. He further declares that opportunity cost should be used when environmental damage is being assessed and that it is mostly less than financial costs Cartwright [4]. In the study he quantifies the economic impact of sea-level rise by using the City's valuation roll as basis to determine a rate per square meter for coastal land. Based on his assumption he calculated the estimated economic loss of private property around the Cape Town coastline at "R3.2 billion for Scenario 1, R19.5 billion for Scenario 2 and R44.5 billion for Scenario 3" Cartwright [4].

Although the basis for the base line (City of Cape Town, Valuation Roll) used by Cartwright [4] is market value he altered the values by calculating averages and establishing weighted averages for land. This approach deviates from valuation theory according to which the final opinion of value should be expressed as a "range of values or single dollar figure derived from the reconciliation of value indications and stated in the appraisal report" Appraisal of Real Estate [17].

The second and latest study was conducted in 2010, commissioned by the Provincial Government of the Western Cape Department of Environmental Affairs and Development Planning: Strategic Environmental Management, with the aim of assessing the risk of sea level rise and flood hazards Umvoto Africa [24]. According to Umvoto Africa "an extreme coastal event comparable to the KZN March 2007 storm could cause damage worth half the total annual budget of the Eden District Municipality and five coastal Local Municipalities combined" Umvoto Africa [24]. There are no clear explanations of how they reached this assumption other than that it is based on the 2009/10 budget of the Eden District Municipality and the associated local municipalities of approximately R2, 5 billion. Based on this figure they determined an economic vulnerability score expressed as a "percentage value of the budget increasing in factors of ten, ranging from 0.0004 % of the total budget (R 1 million – score of 1) to 400 % of the total budget (R 10 billion – score of 5)" Umvoto Africa [24].

The methodologies used in both these studies are not aligned to property valuation theory and methodology, which gives emphasis to market value. It was therefore decided to look at how international studies dealt with a similar situation. A number of studies were found: two in California, USA and one in Sydney, Australia.

In a paper by Heberger et al [25] the replacement value of property are used to estimate the economic impact of sea-level rise. They acknowledge the difference between replacement cost and market value and indicated that market values are higher due to a number of site specific factors whilst replacement value is based on national-average construction costs Heberger et al [25]. According to the authors their analysis was restricted by the limitations related to economic valuation methodology. In their analysis of floods they used the replacement value of buildings and the content thereof to estimate the economic cost of a rise in sea level. It is clearly stated that they did not use the property or land value which are much higher; however, they do say that it should be used if the land is permanently inundated or abandoned. They further commented that replacement value cannot be used to estimate the cost of erosion as erosion is the result of the total loss of property and land. In conclusion they pointed out that a rough estimation of land values along the coast was made but additional studies are needed Heberger et al [25].

In a second paper by King [26] the assessed value was used to determine the economic cost of sea-level rise. The authors drew attention to the fact that data regarding function of age, but also character and condition of assets was not readily available and they therefore valued properties at risk to flooding and erosion using a constant depreciation factor of 25% King et al [26]. They also indicated that “Depreciated replacement values are appropriate for estimating damages to structures, yet the market value of land (which literally falls into the ocean, and cannot be replaced) is a more appropriate estimation to account for land damages associated with upland erosion” King et al [26]. A comment made namely that “The sales comparison approach is an ideal method to use when there are limited market sales but accessible data detailing various site characteristics for all properties” indicate that the authors of this paper are not familiar with the property valuation methodology at all, as the sale comparison approach relies on sales data to determine market value King et al [26].

In an Australian study it is stated that “As the market value of a property is reflected in its land value, the land value can be used to determine the market value and, therefore, vulnerability” Hennecke et al [27]. Although they defined market value as land value plus the value of improvements, it seems as if they ignored the value of improvements and relied on land value alone to indicate market value Hennecke et al [27]. In Australia land value is used as the basis to determine assessment rates in contrast to South Africa where market value is used as the basis to determine assessment rates.

All the studies mentioned above are in agreement that the predicted rise in sea level will result in an economic loss for coastal communities. In their attempts to identify the quantum of the economic loss a variety of methodologies were utilized. However, the well-defined valuation methodology, property valuers use to estimate and develop an opinion of the market value of fixed property was ignored Betts and Ely [18].

The impending problem created by the predicted rise in sea level will have to be considered by property valuers when they interpret and analyse the property market in their efforts to estimate and develop an opinion of the market value of coastal residential property. Property valuers will therefore in future have to consider predicted imminent events in their interpretation and analysis of a specific property market, contrary to Ratcliff’s opinion that ”… long-range forecasts require a long-range market analysis that evaluates past market behaviour over a long enough history to provide the necessary perspective for prophecy” Ratcliff [19]. The methodologies used in the above-mentioned studies differs with the concept of ‘market value’ used by property valuers in accordance with the International Valuation Standards International Valuation Standards Committee [28] and ‘fair value’ as prescribed by International Financial Reporting Standards International Accounting Standards Board [29] as well as the Local Government: Municipal Property Rates Act, Act No. 6 of 2004 South Africa [30]. According to International Valuation Standards, market value and fair value are as a general rule in agreement (International Valuation Standards Committee [28].

Risk associated with the changing climate is on the increase and from the studies reviewed above there is a need to quantify this risk. In these studies a variety of concepts, not related to market value or a manipulated form of market value, was used in their attempts to quantify economic loss. This raises the question this study will attempt to address: How will property valuers change their current practice of looking at past market behaviour to arrive at an opinion of market value to also includes climate change risk which is a predicted future event? According to Ratcliff [19] a property valuer’s primary aim is to understand how humans behave in a specific property market in order to develop reliable inputs. This study therefore aims to identify the knowledge, perceptions and practices of property valuers in the Sedgefield property market regarding the predicted rise in sea level.

## 5 Research design and methodology

The focus of the study is to understand and interpret the extent to which the predicted rise in sea level will affect the decisions made by property valuers in the coastal residential market in South Africa. The study will be conducted from the perspective of a property valuer in the Sedgefield property market. Market participants rely on property valuers to determine the market value of a property they may be interested in buying, selling, bonding, insuring or rating. Property valuers interpret the behaviour of market participants according to valuation theory to determine the market value of immovable property as at the date of valuation. Property valuers are pragmatists who are real-world practice orientated, problem-centred and attentive to the consequences of events or actions which influences a specific property market.

### 5.1 Research design

A mixed methods approach will be pursued by way of a sequential exploratory design, starting with an initial phase of qualitative data collection and analysis followed by a phase of quantitative data collection and analysis. Exploratory research is defined as "a methodological approach that is primarily concerned with discovery and with generating or building theory" Jupp [31].The purpose of this exploratory sequential design will be to develop an in-depth understanding of the phenomenon of a rise in sea level in order to develop an instrument that can be used by property valuers when they assess the market value of coastal residential property.

#### 5.1.1 Research Population and Area

According to the South African Risk and Vulnerability Atlas South Africa [32] an increase in water temperature will lead to increase in sea levels. It also predicts that the changing climate may create storms of greater intensities which will affect coastal settlements. Although the research population is all the coastal residential properties along the South African coastline, Hughes [3] identified four particular areas, namely: Greater Cape Town (Melkbosstrand to Gordon's Bay); the South Cape coast (Mosselbay to Nature's Valley); Port Elizabeth; and the Natal South coast and Greater Durban (Southbroom to Ballitoville) as the area's most vulnerable to a rise in sea level. This was confirmed by Umvoto Africa [24] in a study commissioned by the Western Cape Provincial Government with regard to the climate change risk in the Eden District Local Authority. Sedgefield a small coastal town halfway between George and Knysna was indicated as the most vulnerable town in both studies.

This study will focus on coastal residential properties in Sedgefield. The purpose of the study is to understand and interpret the extent to which the predicted rise in sea level will affect the decisions made by property valuers in the coastal residential market in South Africa. Although Sedgefield will be used as a case study and it is generally accepted that the results of a case study cannot be generalized, property valuers will be able to use the results to assist them when they conduct valuations in other coastal residential areas along the South African coastline.

### 5.2 Methodology

The researcher followed an inductive approach to extract knowledge and perceptions from property valuers with an interest in coastal residential property, to discover if they are aware of the predicted rise in sea level and how they perceive this to impact on coastal residential properties. The second quantitative phase follows up on the qualitative phase for the purpose of determining if the valuer's views are reflected in market practices.

**Phase 1**

Research instrument: Open-ended questions in structured interviews were used to collect data to determine property valuer's knowledge and perceptions regarding climate change and the inclusion thereof when they conduct valuations. According to Cooper and Schindler [33] structured interviews is reliable and valid as it assist the interviewer to remain neutral, allow for a direct comparability of responses and eliminated inconsistency in questions.

A purposive sample was drawn by inviting all registered professional and associated professional property valuers who may conduct valuations in Sedgefield to participate. Of the 44 registered property valuers, 13 property valuers were interviewed.

The 13 interviews were transcribed and the researcher used Atlas.ti to analyse the data collected. Atlas.ti provides software support in the course of data-analysis by assisting the researcher with the coding and annotating activities Henning et al [34].

**Phase 2**

Research instrument: Secondary data i.e. sales data for Sedgefield covering the last 20 years were sourced from the Deeds Office by means of the Property Intellect (a program providing access to the deeds office data) through the UJ library. The sales data were used to establish if market participants (i.e. buyers and sellers) behaviour are in agreement with the knowledge and attitudes of property valuers in the Sedgefield property market. The secondary data provided by Property Intellect are reliable and valid as it is obtained directly from the different Deeds Office's in South Africa. All property transactions are recorded by the deeds offices in accordance with the Deeds Registries Act 47 of 1937 as amended South Africa [35].

A nonprobability procedure was followed to draw a sample of properties in Sedgefield. Although a nonprobability sample is arbitrary and subjective according to Cooper and Schindler [33] this was deliberately done as only properties sold more than once in the last 20 years was needed to establish trends.

The data were analysed in Excel to establish trends in sales prices and to determine the relationship between prices and rising sea levels. This was done by identifying any irregularities in prices shortly after events that may have been contributed to a rise in mean sea level.

## 6 Preliminary conclusion

Sedgefield is a small town situated on the Swartvlei estuary on the Southern Cape coast in South Africa. Sedgefield was identified by Hughes [3] as the urban area most likely to be affected by a rise in sea level in South Africa. The business district and approximately 40% of the residential areas are below five metres above the current mean sea level.

The preliminary conclusion indicates that although the majority of the property valuers interviewed are aware of climate change their knowledge regarding climate change is very general in nature. They are also not concerned about the predicted rise in sea level and unaware of the National Environmental Management: Integrated Coastal Management Act No 24 of 2008 and the impact thereof. They all indicated that they still look at past market behaviour to determine market value of coastal residential property and are of the opinion that the rise in sea level should not be considered at all.

The property valuer’s behaviour (looking at past sales) was observed in phase two. The analysis of the quantitative data indicated a steady increase in market value of properties sold twice and more over the last 20 years. This applied to all sales which include all properties situated just above mean sea level as well as properties flooded in the past.

The preliminary conclusion is that although property valuers are aware of climate change and the predicted rise in sea level, they do not know how to take it into account and therefore ignore the predicted rise in sea level in favour of the historic data they are used to. The researcher believes that one’s he has completed the planned instrument it will provide property valuer’s a methodology to follow.

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## ANNEXURE C

# Exploring Property Valuer's Knowledge, Behaviour and Attitude Regarding Climate Change by means of a Mixed Methods Research Approach

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**Abstract**

**Problem/Purpose:** The emerging nature of climate change and the promulgation of the National Environmental Management: Integrated Coastal Management Act to adapt to and mitigate for the rising sea level by the South African government poses the following question to property valuers. How will property valuers take the risk created by the changing climate and rising sea levels into account when they develop an opinion of value?

Since no previous studies exploring property valuer's experience concerning climate change risk was found in the literature, a phenomenological study exploring property valuers lived experience of the rising sea level was undertaken in order to develop a model to assist property valuers when they value coastal residential real estate.

**Design/methodology/approach:** Property valuer's lived experience regarding the rising sea level was investigate by way of a mixed methods approach employing a two stage sequential exploratory design.

**Findings:** The research provides an insight into the behaviour of property valuers along the Southern Cape Coast and confirmed their dependence on historic data and their anchoring behaviour when they develop an opinion of value. Property valuers disregard of future risk, inherent in the changing climate and the rising sea level, due to an absence of evidence thereof in sales data is a concern.

**Research limitations/implications:** The research is restricted to coastal residential real estate on the Southern Cape Coast of South Africa. The interpretation of the qualitative findings and the quantitative results are that of the researcher and could be subject to a different interpretation by another researcher. As the first study of its nature on the risk posed by rising sea levels and the lived experience of property valuers, the research lacks external validity. Further research may be required to validate the findings.

**Takeaway for practice:** Property valuers and all stakeholders in coastal residential real estate should acquaint themselves with the inherent risk in the changing climate.

**Originality/value:**

This was the first study to explore the lived experience of property valuers regarding the rising sea level. The use of the mixed methods design allowed the researcher to corroborate property valuers stated behaviour within a specific real estate market with sales data.

**Keywords:** mixed methods research, climate change, sea level rise, risk, property valuation,

**Property Research Methods**

# Exploring Property Valuer's Knowledge, Behaviour and Attitude Regarding Climate Change by means of a Mixed Methods Research Approach


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## Introduction

The promulgation of the National Environmental Management: Integrated Coastal Management Act to adapt to and mitigate for the rising sea level by the South African government in 2008 (South Africa, 2008) drew attention to the changing climate and the effect thereof on the market value of immovable property. Cradduck (2016) argues that it is not whether the future risk must be taken into account but rather if property valuers will correctly identify the risk and include it in their valuation reports.

The aim of the research was to explore property valuer's knowledge, behaviour and attitudes concerning the climate change phenomenon and specifically the effect of the rising sea level on the coastal residential real estate market of Sedgefield in South Africa.

Though extensive research has been conducted on climate change and the impact thereof on the environment, limited research has been conducted on the effect of the changing climate on the market value and estimation thereof on immovable property.

A number of studies attempted to quantify the potential risk of climate change on immovable property in economic terms. In two of these studies Hennecke, Greve, Cowell and Thom (2004) and Cartwright (2008a), the economic value of land was based on the average value for land in an entire suburb and no distinction was made with regard to the location of such properties, for example sea front or inland properties. This is contrary to standard valuation practice, which requires a comparison of like with like (Appraisal Institute, 2013).

However, research on the effect of climate change within the property valuation community is lacking. While the effect of flooding on the value of real estate is well researched (Below, Beracha & Skiba, 2015; Turnbull, Zahirovic-Herbert & Mothorpe, 2013; Bin, Kruse & Landry, 2008; Lamond, Proverbs & Hammond, 2009; Lamond, Proverbs & Antwi, 2007a; Lamond, Proverbs & Antwi, 2007b; Lamond & Proverbs, 2006) conducted research, which investigated the impact of flooding and erosion on property prices. Only a few studies specifically refer to the effect of the changing climate on the market value of coastal residential property (Cradduck, 2016; Sheehan, 2012; Bienert, Wagger, & Steixner, 2008; Bin & Kruse, 2006).

Since no previous studies, exploring property valuers experience concerning climate change risk was found in the literature, this phenomenological study, which determine property valuer's lived experience regarding the changing climate and the rising sea level attempted to address the gap in valuation literature.

The central research question, "To what extent does the predicted rise in sea level and ensuing risk thereof affect property valuer's behaviour in the coastal residential real estate market in South Africa and how should property valuers quantify the climate risk?" directed the research.

The lack of historic data regarding climate change and the rising sea level required a departure of the conventional quantitative research approaches applied in property valuation research. This will be discussed in the following section.



**Literature review**

***Research design***

The research design was directed by the pragmatic worldview of a property valuer in the coastal residential real estate market in South Africa. Property valuers are pragmatists who are real-world practice orientated, problem-centred and attentive to the consequences of events or actions, which influences a specific real estate market (Boyd, 2014; McCluskey & Borst, 2007).

In order to understand a specific real estate market property valuers rely on past sales within that market. Information regarding the past sales is acquired in a quantitative data format and analysed using quantitative data analysis techniques. Consequently, property valuers use quantitative data to interpret the behaviour of market participants when they develop an opinion of value. This is in agreement with Levy and Henry's (2003) finding that the majority of articles published in academic real estate journals use quantitative research techniques. Levy (2006) is of the opinion that the use of quantitative research techniques are problematic when the aim of the research is trying to understand or to discover influences associated with a phenomenon. The climate change phenomenon is an example, at present it is still a prediction of what is to come. However, Bienert, Wagger and Steixner (2008) maintains that the changing climate must be taken into account now, as it will restrict the future benefits of an investment in real estate. Levy (2006) argues that if the aim of the research is to develop an understanding of an actual phenomenon a qualitative methodology may be more appropriate (Levy, 2006). Levy's argument and the researchers' pragmatic worldview guided the decision to employ a mixed methods research design in this research.

***Mixed methods research design***

Mixed methods research is "… an approach to inquiry that combines or associates both qualitative and quantitative forms …" (Creswell, 2014, p. 4). Johnson, Onwuegbuzie and Turner (2007) indicate that a mixed methods approach which makes use of both the qualitative and quantitative approaches add to the breadth and depth of understanding of a research problem. Creswell and Plano Clark (2011) are of the opinion that the acceptance of a mixed method design is situated in the harmonious use of both a qualitative and a quantitative approach to secure a better understanding of a research problem, which cannot satisfactorily be resolved, by a qualitative or quantitative approach.

The use of both qualitative and quantitative data provides a better understanding of the influences within a real estate market (Bell & Bell, 2015). Bell and Bell (2015) argues that although real estate can be described in numbers it is people who negotiate and conclude transactions. This confirmed Ihuah and Eaton's (2013) view that mixed methods research was the most appropriate for the research they conducted on the sustainable management of public housing estates.

Hastjarjo (2015) maintain that the incorporation of both qualitative and quantitative data provide a comprehensive understanding of a particular real estate development problem instead of a particular positivist or interpretivist view of the data. While Wong (2016, p. 76) used mixed methods research to examine the robustness of "... *long term determinants on house prices in Melbourne*".

**Methodology**

Owing to the absence of specific valuation, guidelines to account for the rising sea level and the slow onset nature of climate change a two-stage mixed methods research design that explore the knowledge, behaviour and attitudes of property valuers regarding the rising sea level in Sedgefield was employed. An exploratory sequential design was applied in the mixed methods research approach.

The purpose of the exploratory sequential design in this study was to develop an in-depth understanding regarding property valuer's, practicing in Sedgefield, South Africa, knowledge, behaviour and attitude regarding the climate change phenomenon. The research was limited to the effect of the rising sea level and the promulgation of the Integrated Coastal Management Act, by the South African government.

The study commenced with a qualitative inquiry, which explored property valuer's knowledge, behaviour and attitudes regarding the rising sea level in the first stage. Primary data was collected by means of personal interviews with property valuers in the sample area. This was followed by a second stage in which secondary data, sales data from the sample area, was statistically analysed and compared with the results from the first stage. The first stage carried a greater weight than the second stage, which was used as a control to confirm or deny the findings in, stage one. According to Creswell and Plano Clark (2011) the research question, research objectives or a specific research procedure amongst others can influence the weight allocated to either the qualitative or the quantitative method. Creswell (2009) suggest that the aspects of timing, weighting, mixing and theorizing should be considered before choosing a strategy.

The first to consider is timing that is to decide on the sequence in which the approaches (qualitative or quantitative) will be applied, which one first or will they be applied concurrently (Creswell, 2014). In this study, a sequential approach was followed, commencing with the qualitative approach and followed by the quantitative approach.

The second aspect is the weighting; the weighting is an indication of the order of importance as the approach with the highest weighting will normally be an indication of the emphasis of the study (Creswell, 2014). As indicated in the research question this study is concerned with the behaviour of property valuers and therefore the qualitative stage carries more weight than the quantitative stage. Eighty percent of the weight is allocated to the qualitative stage and 20% to the quantitative stage.

The third aspect applies to the mixing of the data. Mixing of data may occur during data collection, analysis or interpretation or in all three (Creswell, 2014). The data was collected, analysed and interpreted separately where after the results was compared to come to a conclusion.

The fourth aspect to consider is theorising i.e. is the research design driven by a theory, in this study the research design was influenced by property valuation theory (Creswell, 2014).

The decision to use a sequential exploratory design was influenced by property valuation theory. Property valuers interpret human behaviour when they develop an opinion of value (Ratcliff, 1979). To develop this opinion of value they rely on different sources, mostly qualitative in nature, as well as on property sales data, quantitative data, when they use the sales comparison approach. According to Ayittey, Gyamfi-Yeboah and Gambrah (2006) property valuers depend mostly on quality scripted data rather than numeral data when they develop an opinion of value.

Mixing of data is typical for property valuers as they are constantly collecting both qualitative and quantitative data. The mixed methods design allowed the researcher to triangulate the data to determine if the findings in the qualitative inquiry (stage one) are confirmed or refuted by the results of the quantitative inquiry (stage two) (Saunders, et al., 2016). The research question and objectives applied in the mixed methods design were shaped by valuation theory and the processes described in the literature review.

The sequential exploratory design comprises two stages. In the first stage, a phenomenological research strategy was pursued to gain insight into property valuer's knowledge, behaviour and attitudes regarding the changing climate and the risks associated therewith. In the second stage, a case study research strategy was followed to establish if the knowledge, behaviour and attitudes of property valuers are a reflection of the current coastal residential real estate market in Sedgefield.



***Stage one: Phenomenological research and qualitative inquiry***

Phenomenological research aim to describe the lived experience of the participants in a study (Maypole & Davies, 2001; Robinson & Reed, 1998; Greene, 1997). Phenomenology therefore investigates an event like the changing climate from an individual's point of view (Lester, 1999). Levy (2006, p. 369) argues that "*real estate academics*" should not restrict their research to quantitative studies only but to investigate the "*behavioural aspects*" of real estate markets by conducting qualitative studies.

The qualitative inquiry investigated the knowledge, behaviour and attitudes of property valuers regarding the risk inherent in the rising sea level and the effect of the Integrated Coastal Management Act on property valuation practices in Sedgefield, South Africa over a period.

***Qualitative data collection and analysis***

*Data collection.* The southern Cape coast were purposefully chosen as the research area as the southern Cape coast was identified by Hughes (1992) as one of four particular areas along the South African coast vulnerable to the rising sea level. Sedgefield was chosen as the research site, due to its vulnerability to the rising sea level (Umvoto Africa, 2010c; Hughes, 1992), number of floods experienced since 2003 in 2003, 2006, 2007 and 2015 (Kirsten, 2015). Property valuers conducting valuations in this area should therefore be the first to encounter the effect of the rising sea level on coastal residential properties.

Primary data was collected through one on one interviews from a sample drawn from the registered property valuers who may engage in the valuation of coastal residential properties along the South African coastline. Purposeful sampling allows the researcher to select participants who and locations, which have experienced the phenomenon being, studied (Creswell & Plano Clark, 2011).

The South African property valuer's population comprise 1903 property valuers, which include candidate (591), associated professional (587) and professional valuers (725). A non-probability purposeful sample were drawn by inviting all registered professional and associated professional property valuers who regularly conduct valuations along the southern Cape coast and Sedgefield to participate.

The South African Council for the Property Valuers Profession's membership list were used to identify registered professional and associated professional property valuers (44 valuers) in the municipalities of Knysna, George, Mosselbay and Eden District Municipality as they are the most likely to conduct valuations on the southern Cape coast and in Sedgefield, 13 consented to be interviewed. The participants are professional valuers and associated professional valuers registered with the South African Council for the Property valuers Profession and in within close proximity of the research site, namely Sedgefield.

Semi-structured interviews with closed- and open-ended questions were used as research instrument to collect data. The semi-structured interview directed the interviews with property valuers working in the southern Cape coast.

The open-ended questions in the semi-structured interview allowed themes to emerge from the interview narratives (Miles & Huberman, 1994). The purpose of the open-ended questions in the semi-structured interview was to allow the researcher to interrogate the property valuer's knowledge, behaviour and attitudes regarding the changing climate, specifically the rising sea level, and the presence thereof when they develop opinions of value.

The semi-structured interview schedule assisted the researcher to remain neutral and allow for a direct comparison of the responses and eliminated inconsistency in questions ensuring reliability and validity (Cooper & Schindler, 2008).



*Data analysis.* The data was analysed according to the coding process for qualitative data as described by Saldaña (2012). In the first cycle, holistic coding was applied to identify broad topic areas. In the second cycle, the broad topics were subdivided into 28 descriptive codes while pattern coding was applied in the third cycle to categorise the codes and theme the data (Saldaña, 2012).

Although the intention was to use AtlasTi to analyse the data the researcher manually analysed the data manually due to the number of interviews, funding, time and the fact that 11 of the interviews was conducted in Afrikaans, and not English. The majority of the participants elected to conduct the interviews in their home language, Afrikaans.

***Stage two: Case study research and quantitative inquiry***

The aim of the case study research was to establish if the knowledge, attitudes and behaviour of property valuers regarding the rising sea level and the Integrated Coastal management Act are a reflection of the current market behaviour in Sedgefield. According to Ratcliff (1979) property valuers interpret human behaviour when they develop an opinion of value. Property valuer's opinion of value in the Sedgefield real estate market should therefore be a reflection of how market participants (buyers and sellers) behave in Sedgefield's real estate market.

Two areas within Sedgefield were selected, sales data was collected from both areas over the last 20 years and statistically compared to ensure that the two areas were comparable.

***Quantitative data collection and analysis***

*Data collection.* Secondary data, sales data for the last 20 years was sourced for two suburbs in Sedgefield from the South African Property Transfer Guide (SAPTG).

A nonprobability procedure was followed to draw a purposeful sample of properties from the two suburbs, The Island and Sedgehill, in Sedgefield. The Island is generally lower than 5 metre above mean sea level, thus vulnerable to a rise in sea level and the Sedgehill higher than 5 metre above mean sea level, and thus not vulnerable to the rising sea level. The comparability of the two selected areas in Sedgefield were statistically confirmed, by way of descriptive statistics.

The sample for the quantitative inquiry in the study was deliberately selected as only properties that sold more than once in the last 20 years was necessary to establish trends in sales prices and to determine if there are any relationship between selling prices flood events and rising sea levels or events that can be linked to climate change.

*Data analysis.* Non-parametric statistical tests were conducted on the two data sets, Sedgefield Island and Sedgehill, to establish if past floods, height above sea level and distance to the water had any influence on the behaviour of purchasers and sellers in the specific real estate markets.

The findings of the qualitative data and the results of the quantitative data are presented in the next section.

**Findings and results**

The findings and results for each stage in the mixed methods research design are reported separately, with the qualitative inquiry first and the quantitative inquiry second.

***Qualitative inquiry***

The qualitative inquiry revealed that although the participants have noticed changes in the environment they not necessarily ascribe it to climate change or the rising sea level and generally consider sea-level rise risk as something that will happen in the future. '*I don't know – not in my lifetime …*' (P1), '*Only when the market starts reacting to the specific risk to the property*' (P3), '*Must be taken into account in the future …*' (P5)

It was evident that the participants knowledge regarding legislation and the impact thereof is limited. The participants clearly stated that as long as they do not find evidence of sea-level rise risk in the real estate market they would keep on ignoring the effect of climate change on value. '*The market determines the value'* (Translation) (P10). This was confirmed by another participant '*The principles of valuation will not change … because a purchaser will take these into account*' (P9). Participant six admitted that 'Comparable market transactions will not be sufficient.' another participant stated it bluntly that he will not consider it '… *unless* *there can be a very well reasonable and thought out protocol for it*' (P2). Other responses in this regard were that there should be a change in 'policy' (P11)

***Quantitative inquiry***

The results of the quantitative data confirmed the main finding in the qualitative data namely that the property market in Sedgefield has not taken notice of the changing climate and that the negative effect of the rising sea level and it consequential risks are not reflected in the sales prices of coastal residential real estate in Sedgefield, South Africa.

The skewness in the data is visible in the histograms in Figures 1 and 2. The skew data can be related to the fact that only repeat sales over the last 20 years were used  to establish if there are a trend and if there were any changes in property sales and prices   after specific events.

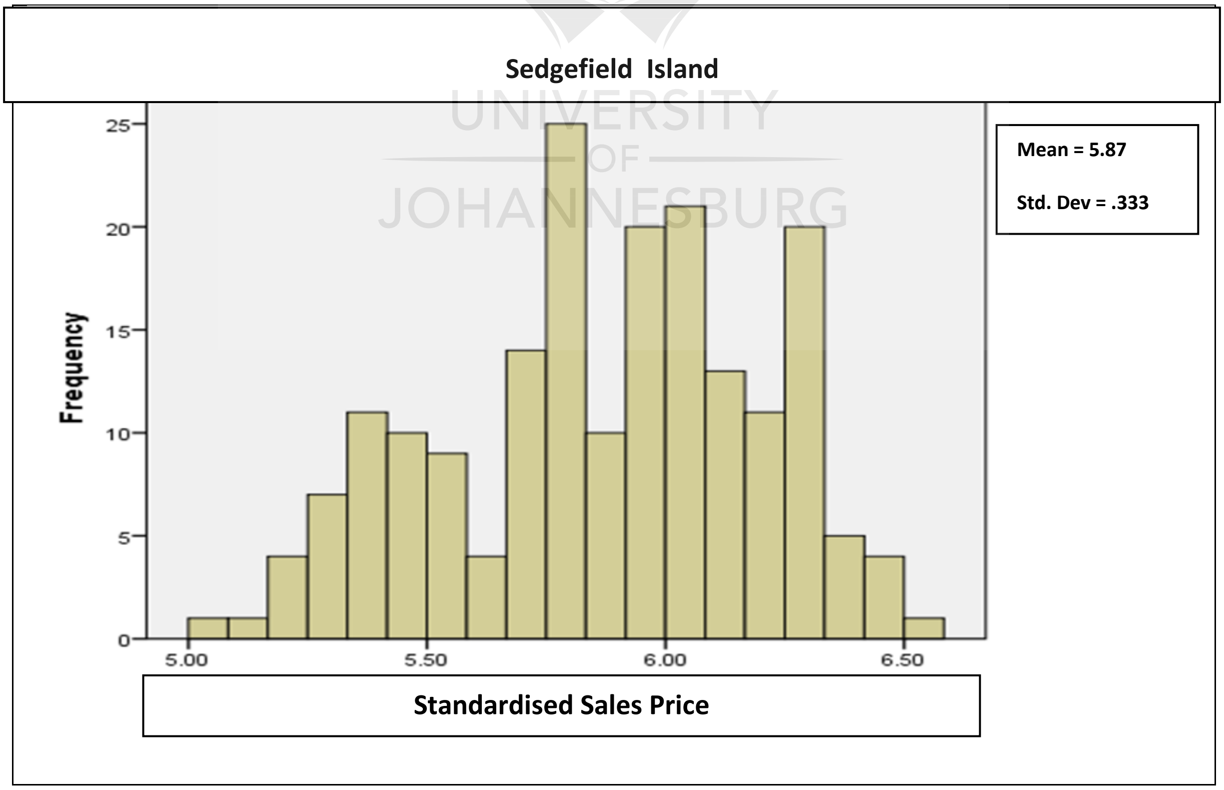


**Figure 1: Standardised sales price in the study site (CPI adjusted to 2012, 2012 =100, log10)**

***Source:*** *Survey data*

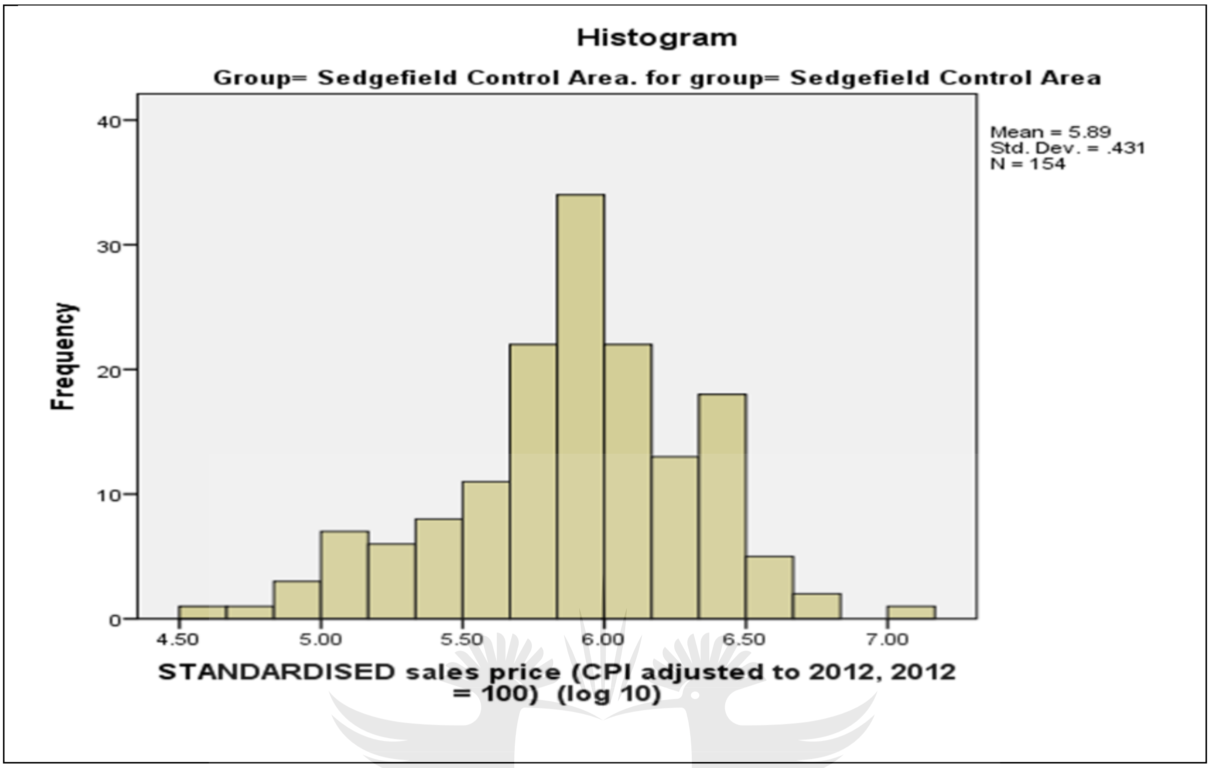


**Figure 2: Standardised sales price in the control site (CPI adjusted to 2012, 2012 = 100, log10)**

***Source:*** *Survey data*

The results of the statistically analysis of the independent-samples t-test, Mann-Whitney U test and Kruskal-Wallis tests indicated that there are no significant difference between the two sites. Non-parametric tests were conducted because the data was not normally distributed. No evidence of events that might have influenced the property market in Sedgefield were found. The only visible trend was a steady increase in property prices from 1990 to 2008 when the global financial crisis resulted in a sharp decline in property prices at both sites.

It was concluded that the height above mean sea level and the distance to the high-water mark do not affect the selling price of a subject property. Pearson product-moment correlation coefficient and Spearman rho tests did not reveal any effect of the height above mean sea level and the distance from the high-water mark on property prices at both sites.

**Conclusion**

The qualitative inquiry revealed that the participants are unaware of the implications pertaining to the latest legislation promulgated by the South African government to adapt or mitigate for climate change. The participants also indicated that they would consider sea level rise risk only when it manifest in a particular real estate market and not before, thus ignoring Bienert, et al. (2008) warning that property valuers will have to include the declining future benefits of an investment in property.

The quantitative inquiry confirmed the qualitative findings, that the property market in Sedgefield has not taken notice of the changing climate and that the negative effect of the rising sea level and it consequential risks are not reflected in the sales prices of property in Sedgefield.

This paper acknowledges amongst others the following limitations. It was never the intention of the research to generalize because the research is restricted to coastal residential real estate on the Southern Cape Coast of South Africa. The interpretation of the qualitative findings and the quantitative results are that of the researcher and could be subject to a different interpretation by another researcher. As the first study of its nature on the risk posed by rising sea levels and the lived experience of property valuers, the research lacks external validity. Therefore, further research may be required to validate the findings.

The research findings highlighted a number of implications for property valuers, purchasers and sellers, estate agents, financial institutions and local authorities. The research indicated that property valuers would have to update their knowledge regarding the changing climate, the rising sea level and recently promulgated environmental legislation.

This was the first study to explore the lived experience of property valuers regarding the rising sea level. The use of the mixed methods design allowed the researcher to corroborate property valuers stated behaviour within a specific real estate market with sales data. The research thus did not simply provide an empirical description of the specific real estate market, but attempted to overcome what Levy (2006, p. 369) refer to as '… the positivist methodological bias …'. The results support Levy's (2006) contention that the real estate academic community should conduct research, which will allow them to interpret and understand real estate markets instead of, provide empirical descriptions only.

The study focused on the valuation of coastal residential real estate. The effect of the rising sea level on the market value of coastal residential real estate in South Africa was explored and the findings indicate that property valuers pay no attention to the rising sea-level risk. This can have far-reaching consequences for the coastal real estate market and the South African economy. The research thus provides an insight into the behaviour of property valuers along the southern Cape coast and confirmed their dependence on historic data and their anchoring behaviour when they develop an opinion of value.

### Disclosure statement

No potential conflict of interest was reported by the author.



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**ANNEXURE D**

# Climate Change Risk Coefficient for Coastal residential Real Estate

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**Abstract**

**Problem/Purpose:** The changing climate and specifically the rising sea level presents a risk to the future benefits of coastal residential real estate. The purpose of this paper is to propose a model property valuers can employ to derive a risk coefficient for properties at-risk of being permanently inundated due to the rising sea level.

**Design/methodology/approach:** A mixed methods approach employing a two stage sequential exploratory design was applied to investigate property valuer's lived experience regarding the changing climate and the rising sea level.

**Findings:** The findings indicate that property valuers pay no attention to the risk posed by the rising sea level and this can have far-reaching consequences for the coastal real estate market and the economies of coastal towns in South Africa.

**Research limitations/implications:** The research is restricted to coastal residential real estate on the Southern Cape Coast of South Africa. The proposed model reflects the researchers attempt to determine a risk coefficient and could be subject to a different interpretation by another researcher. As the first study of its nature on the risk posed by rising sea levels on property market values, the research lacks external validity. Further research may be required validate the findings.

**Takeaway for practice:** The model provides property valuers with an uncomplicated approach to identify at-risk coastal residential real estate and an objective methodology to derive a coefficient based on the risk of rising sea levels.

**Originality/value:** This research was the first to explore the effect of the rising sea level on the market value of coastal residential real estate in South Africa. It is also the first to provide property valuers with a model they can apply to quantify the rising sea level risk for a specific at-risk property.

**Keywords:** model, climate change, sea level rise, risk, risk coefficient, property valuation,

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## Introduction

Global warming and climate change is a reality with 2016 globally the warmest year yet recorded since 1880 (NASA, 2017, p. 1). According to (NASA, 2017) the sea level has globally risen with 88,2mm since 1993. It is therefore important that property valuers consider the rising sea level risk and uncertainty when they develop opinions of value for coastal residential real estate.

The market value of real estate is affected by present-day and future uncertainties (Adair and Hutchison, 2005). While French (2007) advocates that uncertainties are present when property valuers develop an opinion of value. Adair and Hutchison (2005, p. 254) further argues that '… risk and uncertainty is inherent in the valuation process.'

Uncertainty is defined by Byrne (2002, p. 8) as '… anything that is not known about the outcome of a venture at the time when the decision is made.' and risk as '… the measurement of a loss identified as a possible outcome of the decision'.

While Al-Marwani (2014) postulate that risk is an element present in any investment in real estate. This is similar to Wight and Ghyoot's (2005, p. 137) argument that since the real estate environment change over time it result in '*environmental (location) risk*'. They further suggest that due to environmental risk's connection to a specific location it is unmanageable and can have a substantial impact on an investment in real estate (Wight & Ghyoot, 2005). Frew and Wilson (2002, p. 1) also emphasised the importance of location when they maintains that '*Location has always been an important determinant of a property's value*.' The value of real estate is thus influenced by the immobility of its location according to (Zabel, 2004). The risk in real estate investments can be reduced if prime locations are chosen Nitsch (2006)

The effect of the changing climate and the rising sea level was researched in a study conducted in Sedgefield, South Africa. Sedgefield was identified as one of the area's most vulnerable to the changing climate and rising sea level along the South African coastline

(Hughes, 1992). A mixed methods study was conducted in which property valuer's knowledge, behaviour and attitudes were explored. The results of the research culminated in the development of the model presented in this paper.

## Literature review

The assessment of risk and uncertainty has long been at the centre of the debate regarding investment in real estate according to Lorenz, Trück and Lützkendorf (2006), Adair and Hutchison (2005), French and Gabrielli (2004) and Mallison and French (2000). D'Alpaos and Canesi (2014) have highlighted the lack of a specific methodology to assess risk in real estate investment. They ascribe this to the difference in risk assessment between financial investments and investment in real estate (D'Alpaos & Canesi, 2014).

According to Koubkov (2015), there are many uncertainties in real estate investments. Sea-level rise risk is one such new uncertainty and risk, which has not yet been addressed in property valuation literature.

In the current literature, researchers rely on historic data to predict what will happen in a specific real estate market in the near future. The emerging nature of climate change and the promulgation of the National Environmental Management: Integrated Coastal Management Act (ICM Act) to adapt to and mitigate for the rising sea level, raised the question to what extent and how well established valuation processes and procedures will be affected by the changing climate and rising sea levels.

In the model presented below the researcher, demonstrate how property valuers may address the uncertainty and risk created by the rising sea level. The model consists of two sections. In the first section, the elements, which affect at-risk real estate, will be identified and a qualitative rating scale proposed. The second section of the model will introduce a sea-level rise risk equation that property valuers can apply when they conduct valuations of coastal residential real estate.

The problem property valuers are faced with is that the rising sea level will diminish the future benefits of at-risk coastal residential real estate to zero. Domain, Wolf and Yang (2015) postulate that residential real estate is in general the most frequently possessed asset. While Du Preez, Balcilar, Razak, Koch and Gupta (2016) argues that 29,4% of South Africans assets are located in residential real estate. According to the Appraisal Institute a decision to invest in real estate is based on the principal of anticipation "*... value is created by the anticipation of benefits to be derived in the future."* (Appraisal Institute, 2014, p. 27). Brown and Klingenberg (2015) argues that investors are motivated by the anticipation of a future return that is higher than the current value, when they invest in real estate. Although it is not yet visible in the market, the rising sea level and the promulgation of the Integrated Coastal Management Act affect the future expectations for at-risk properties in the coastal residential real estate market in South Africa.

The ICM Act was promulgated in 2008 and amended in 2014, it has not been implemented yet and it may be one of the reasons why coastal real estate market has not responded to the sea-level rise risk (South Africa, 2014). The implementation of the Act in the Western Cape has been delayed by a lack of funding and the initial difference between pilot projects. The public participation process prescribed by the Act also delayed the implementation.

The ICM Act requires that a coastal protection zone which, reaches 100m inland from the high-water mark in urban areas and a 1 000m inland in rural areas be implemented. The coastal protection zone further includes all land that will be inundated during a 1/50 year flood, caused by a storm event (South Africa, 2009). The height above mean sea level and the distance of a property from the high-water mark will consequently have an influence on the risk such property is exposed to. The ICM Act emphasise the risk of investing in coastal residential property (South Africa, 2008).

The introduction of coastal setback lines is perceived to be a sustainable method to adapt to the future impact of the rising sea level (Mather, 2007; Schoonees, Lynn, Le Roux and Bouton, 2008 and Theron, Rossouw, Barwell, Maherry, Diedericks and De Wet, 2010).

Kavonic (2013) argues that the delineation of setback lines will have a socio-economic impact on properties within the no development zone. She submits that the rights of property owners and property values will be affected (Kavonic, 2013; Cartwright, 2008 and Breetzke, et al., 2012). Cartwright (2008) who also suggests that the introduction of new setback lines may spearhead a decline in revenue for local authorities due to decreased property values and increase in the maintenance of infrastructure previously confirmed this.

Identifying the predicted physical impact of climate change is straightforward. However, quantifying the economic impact of climate change and the adaptation and mitigation measures are challenging, especially the impact of the rising sea level on coastal residential property.

None of the property valuers with whom interviews were conducted indicated that they consider the impact the rising sea level or the implementation of the ICM Act when they develop an opinion of value. Fitchett, Grant and Hoogendoorn (2016) found a similar attitude in a study they conducted in two small towns on the Eastern Cape coast of South Africa.

The examination of the sales data in Sedgefield did not provide any indication that purchasers and sellers of residential real estate in the study area, Sedgefield are concerned about the implications of the rising sea level or the promulgation of the ICM Act.

The slow onset nature of the rising sea level will have to be taken into account when property valuers develop an opinion of value for coastal residential real estate. This raises the question of how property valuers should deal with rising sea-level risk.

*Influences of rising sea-level risk*

Coastal residential real estate's exposure to the rising sea level will be affected by a properties height above mean sea level, the distance from the high-water mark and time.

The three influences height above sea level, distance from the high-water mark and time will be incorporated in the rising sea-level risk model considered below. These influences are normally not explicitly considered in the valuation process.

*Height above sea level.* The impact of flood plain location on value is well researched, Bélanger and Bourdeau-Brien (2016), Lamond, Proverbs and Hammond (2009) and Hallstrom and Smith (2005) among others.

The influence of the height above sea level by itself on value has not been researched. The height above sea level is of special importance to this study area as it is on average not more than 5m above mean sea level and partly surrounded by the Swartvlei estuary.

The probability that properties, which are situated closer to mean sea level, will be permanently inundated is greater than those, which are situated higher up. The height above mean sea level will therefore be one of the elements of the rising sea level, which can have a negative impact on property values and should be taken into account by property investors.

*Distance from the high-water mark.* A number of researchers examined the influence of the distance from the water to a water view, Jim and Chen (2009), Bin, Crawford, Kruse and Landry (2008), Samarasinghe and Sharp (2008), Bourassa, Hoesli and Sun (2005) and Benson, Hansen, Schwartz and Smersh (1998) amongst other.

The ICM Act do not allow any development within a 100m from the high-water mark indicate that properties situated closer to the high-water mark. Properties situated close to the water and just above the current mean sea level will have a higher risk while those more than five metre, above mean sea level, and further than 100 metres from the high - water mark will have a smaller risk of being inundated. Height above mean sea level and the distance from the high-water mark should therefore be included in any risk equation.

*Time.* The slow rate at which the sea level is rising should also be taken into account. Umvoto Africa (2010c) estimated a sea level rise of 0.75 m by 2050 and one metre by 2100 along the southern Cape coast. Umvoto Africa's estimates is based on the IPCC's sea level rise predictions for the 21st century, i.e. until 2100 (IPCC, 2013). The IPCC (2013), Lorbacher, Marsland, Church, Griffies and Stammer (2012) and (Rahmstrof, 2007) established that the sea level is rising at approximately 3,2mm per annum.

Church, et al. (2013) argues that higher sea levels will increase the intensity and frequency of storm surges. They postulate that the return period for storm surges will also become quicker (Church, et al., 2013).

The years 2050 and 2100 may seem far of however, if the average period of a bond, 20 to 30 years is taken into account 2050 is just 35 years ahead. Property valuers should therefore be attentive to the affect time will have on the remaining useful life of an at-risk property.



It is suggested that the probability of a 1/100 year flood be used, that is a 1% probability that a property may be flooded in any given year, to determine the influence of time (Holmes & Dinicola, 2010). This is also in agreement with the 1/100 year risk projection used by the Western Cape Government in the delineation of coastal management lines (Van Weele, Breetzke, & Steenkamp, 2015).

**At-risk value model**

The aim of the model is to quantify the at-risk value of coastal residential real estate that are exposed to the rising sea level risk. The model is based on the valuation framework Jackson (2003) proposed for the valuation of environmental contaminated properties.

According to the Appraisal Institute (2014) there are three influences that affects the value of contaminated property namely, cost, use and risk influences. These influences are included in the following formula:

*"Impaired value = Unimpaired value – cost effect – use effect – risk effect"*

(Jackson 2003, p. 314).

Jackson (2003) postulate that the unimpaired value is typically estimated by means of one of the traditional approaches, comparable sales, income capitalization or cost. However, he argues that in the case of an environmental contaminated property, the traditional approaches cannot be applied and an alternative approach must be followed due to limited data and other restraining factors (Jackson, 2003). Jackson (2003) maintains that the approach must still be grounded in appropriate market data.



When the influence of the rising sea level is considered, it is the lack of appropriate market data, which produce the problem for property valuers. The environmental risk imagined by the rising sea level is based on the predictions by natural scientists and the requirements of the ICM Act.

With reference to Jacksons' (2003) argument above the researcher, present the following risk model:

At-risk value (ARV) = market value (MV) x suggested risk coefficient

At-risk Value = market value (MV) x suggested risk coefficient at date of valuation, represented by $f$ (MV, $X_1$, $X_2$, $X_3$) = MV x ($X_1 + X_2 + X_3$) / 3

$X_1$ = height above mean sea level, $X_2$ = distance from the high-water mark and $X_3$ = Time (or the rate of sea level rise).

A linear function was used as it is in line with the predictions made regarding the changing climate and the rising sea level are based on the results of linear models (Knutti & Rugenstein, 2015 and Vermeer & Rahmstrof, 2009).

The purpose of the model is to determine the at-risk value of a coastal residential property. To accomplish this the property valuer will commence by determining the market value of the subject property according to the market approach as defined by the IVS. The market approach "*... provides an indication of value by comparing the subject asset with identical or similar assets for which price information is available"* IVSC (2013, p. 5).

A property valuer will apply the comparable sales approach using appropriate market data of similar properties, to develop an opinion of value for the at-risk subject property without the rising sea-level risk. This is in agreement with the current practice of the property valuers in the study area. The next step would be to determine the risk coefficient and multiply it with the market value.

A risk factor for each of the three predicted influences, which constitute rising sea-level risk namely, the height above sea level, the distance to the high-water mark and time, will be applied in the equation. The arithmetic mean of the influences will be determined and used as the risk coefficient.

The tables below provide a reference, which property valuers can use to obtain a risk factor to apply in the equation. Table 1 indicate the probability of the subject property being flooded in relationship with its height above mean sea level.

TABLE 1: Probability of inundation risk

| Height above mean sea level | 1/50-years | | 1/100-years | |
|---|---|---|---|---|
| | Probability (%) | Risk factor | Percentage | Risk factor |
| 0m | 100 | 1 | 100 | 1 |
| 1m | 80 | 0.80 | 99 | 0.99 |
| 2m | 60 | 0.60 | 98 | 0.98 |
| 3m | 40 | 0.40 | 97 | 0.97 |
| 4m | 20 | 0.20 | 96 | 0.96 |
| 5m | 1 | 0.01 | 95 | 0.95 |
| 6m | | | 94 | 0.94 |
| 7m | | | 93 | 0.93 |
| 8m | | | 92 | 0.92 |
| 9m | | | 91 | 0.91 |
| 10m | | | 90 | 0.90 |
| Source: Researcher's calculations | | | | |



*Height above sea level.* Table 1 provide the probability, expressed as a percentage, as well as the risk factor, which should be used in the model. The 1/50 and 1/100 year flood lines were used to calculate the probability that a specific property will be flooded once in 50 or once in a 100 years (Holmes & Dinicola, 2010 and Van Weele, Breetzke, & Steenkamp, 2015). The flood lines are closely linked with the height above mean sea level in that the 1/50 year flood line is represented by the five meter above mean sea level contour. The 1/100 year flood line is represented by the 10 meter above mean sea level contour. The table indicate that an at-risk property located one metre above mean sea level has an eighty present probability of being flooded within the next 50 years. While the same property has a 99% probability of being flooded in the next 100 years. The probabilities are also expressed as risk factors that will be applied in the proposed model. The broad parameters, 1/50 and 1/100 years, afford a property valuer flexibility to decide on the level of risk he/she assume once they have familiarised themselves with the physical situation regarding the subject property.

It is anticipated that property valuers will initially tend to be conservative in their estimation of the risk and apply the risk factors for a 1/100 year flood. However, as the effect of the rising sea level become more visible they may revert to the less conservative 1/50 year flood risk.

*Distance to high-water mark.* Either a one or a zero indicates the distance to the high-water mark. If a subject property is within a 100m or less from the high-water mark, a one is awarded and if it is further than 100m a zero is awarded in the proposed model.

*Time.* The IPCC predicts that the sea level is rising at approximately 3,2mm per annum while Umvoto Africa (2010c) considered a sea level rise of 0.75 m by 2050 and two metre by 2100.

According to the IVSC (2017, p. 82), property valuers are responsible to identify any "*… actual or potential environmental risks …*" during their investigation in the valuation process. It is argued that property valuers should not only identify the risk but also pay attention to the affect time will have on the remaining useful life of an at-risk property.

If the principles underlying the 1/100 year flood line is applied, there is a 1% probability that an at-risk property may be flooded once in 100 years. Every year the at-risk property is not flooded increase the probability of being flooded with 1%. This suggest that the risk of being flooded increase over time. Although it is at present a very small risk, the risk will increase over time. As the risk increases, the future benefits that can be derived from the at-risk property will diminish. Table 2 at the back provide the risk factors in a linear format until 2100 and expected 100% inundation of an at-risk property.

The risk factors indicated in Table 2 were calculated assuming that an at-risk property will be permanently inundated by the rising sea in 2100. The second assumption that influence the risk factor is the assumption that the likelihood of the premises being inundated increases as time goes by.

The problem created by the rising sea-level risk is that there is currently no relevant market data property valuers can count on to inform their opinion of value. The repeat sales data collected and analysed in the study area indicated that flooding events did not have a negative impact on property prices. The trend indicated a positive increase in property prices.

The suggested at-risk value model utilizes data, other than market data, namely the height above mean sea level, distance to the high-water mark and time, to quantify the rising sea level risk. The model provide property valuers with an objective framework to determine a risk coefficient for coastal residential properties that are at risk of being inundated.

**Valuation framework for rising sea-level risk**

The aim of the at-risk value model is to provide property valuers with a framework they can use to bring the three risk factors together into one risk coefficient. Property valuers who work along the southern Cape coast indicated that they do not consider climate change and the rising sea level risk because they have nothing to compare with or anchor it. The three potential risk factors, height above sea level, distance to the high-water mark and time, provide them with a framework within which they can operate, when they develop on opinion of value of at-risk properties

The first step in the framework would be to develop and opinion of the market value of the subject property (an at-risk property) on the date of valuation based on relevant market data. The appropriate approach is the sales comparison approach. During the investigation, the property valuers should identify actual or potential environmental risks by consulting Table 3.

The average risk as indicated in Table 3 provide an indication of the level of the average risk, very low, low, moderate, high or very high and also provide secondary information the property valuer can use as a starting point to make a decision regarding the level of risk. The average risk is derived from sea level rise induced erosion and inundation, ground water contamination and extreme events (Umvoto Africa, 2010c).

As soon as the property valuer has established that the subject property is at-risk, they can apply the proposed at-risk value model to measure the impact of the rising sea-level risk on the subject property.

Risk factors for the height above sea level and time can be acquired from Tables 1 and 2 respectively. While the risk factor for distance from the high-water mark is either one or zero, one if it is 100 metre or less from the high-water mark and zero if it is further than 100 metre from the high-water mark.

The model will typically be applied in the following settings:

Setting one: A property valuer establish that the market value of the subject property is R1 000 000,00 according to the market approach. During his or her investigation the property valuer, find that the subject property is at-risk of being inundated in future and the risk is high, as per the average risk indicated in Table 3. The property valuer also confirm that the subject property is situated one meter above sea level and within 100 meters from the high water mark. The property valuer are of the opinion that the subject property will be inundated by 2100. The property valuer apply the model with the information provided above:

At-risk value (ARV) = MV x risk coefficient

The suggested risk coefficient $f$ (MV, $X_1$, $X_2$, $X_3$) = MV x ($X_1$ + $X_2$ + $X_3$)/ 3

For example if the market value is R1 000 000.00 x (1m + 100m + 2017) / 3

= R1 000 000.00 x (0.80 + 1 + 0.18) / 3

= R1 000 000.00 x (1.98/3)

= R1 000 000.00 x 0.66

= R660 000.00

The at-risk value of the subject property is thus R660 000.00 at the date of valuation.

Setting two: A property valuer establish that the market value of the subject property is R1 000 000,00 according to the market approach. During his or her investigation the property valuer, find that there is a moderate risk that the subject property will be inundated in future, as per the average risk indicated in Table 3. The property valuer also confirm that the subject property is situated two metre above sea level and 300 metre from the high water mark. The property valuer are of the opinion that the subject property will be inundated by 2100. The property valuer apply the model with the information provided above:

At-risk value (ARV) = MV x risk coefficient

The suggested risk coefficient $f$ (MV, $X_1$, $X_2$, $X_3$) = MV x ($X_1$ + $X_2$ + $X_3$ ) / 3

For example if the market value is R1 000 000.00 x (2m + 300m + 2017) / 3

= R1 000 000.00 x (0.60 + 0 + 0. 18) / 3

= R1 000 000.00 x (0.78/3)

= R1 000 000.00 x 0. 26

= R260 000.00

The at-risk value of the subject property is thus R260 000.00 at the date of valuation.

**Conclusion**

Risk and uncertainty was discussed and the property valuer's predicament concerning sea level rise risk and uncertainty in the valuation process highlighted. The use of different models to quantify both positive and negative environmental influences on property was examined and the use of such models to quantify sea-level rise risk argued. The assessment of risk and uncertainty and the lack of a specific methodology to assess sea level rise risk in real estate was emphasised. The use of Umvoto Africa's (2010c) risk rating in 'Table 3: Summary of coastal zone management unit hazard risk scores, highest to lowest risk' was recommended to property valuers as a point of reference to identify at-risk real estate along the southern Cape coast.

The findings indicate that property valuers pay no attention to the risk posed by the rising sea level and this can have far-reaching consequences for the coastal real estate market and the economies of coastal towns in South Africa. The research is restricted to coastal residential real estate on the Southern Cape Coast of South Africa. The proposed model reflects the researchers attempt to determine a risk coefficient and could be subject to a different interpretation by another researcher. As the first study of this nature on the risk posed by rising sea levels on property market values, the research lacks external validity. Further research may be required validate the application of the model. The proposed model provides property valuers with an uncomplicated approach to identify at-risk coastal residential real estate and an objective methodology to derive a coefficient based on the risk of rising sea levels. This research was the first to explore the effect of the rising sea level on the market value of coastal residential real estate in South Africa. It is also the first to propose a model property valuers can apply to quantify the rising sea level risk for a specific at-risk property.

The proposed model is an attempt to enable property valuers to quantify sea-level rise risk and include a considered risk coefficient in their valuation reports. Property valuers who apply the model will be able to include a risk coefficient arrived at, with a degree of clarity and certainty and avoid any bias.

The proposed model may also provide purchasers, sellers, financial institutions and local authorities in the coastal real estate market with a transparent model to enable them to determine an unbiased sea-level rise risk coefficient for individual properties. However, the proposed model should by no means be seen as definitive but rather as the beginning of a debate, in the property valuation community, regarding the impact of the rising sea level on the future benefits of coastal residential real estate.

**Annexure 1:**

**TABLE 2: Risk factor years remaining**

| **Current year** | **Year value zero** | **Years remaining until 2100** | **Risk factor** |
|---|---|---|---|
| 2000 | 2100 | 100 | 0.01 |
| 2001 | 2100 | 99 | 0.02 |
| 2002 | 2100 | 98 | 0.03 |
| 2003 | 2100 | 97 | 0.04 |
| 2004 | 2100 | 96 | 0.05 |
| 2005 | 2100 | 95 | 0.06 |
| 2006 | 2100 | 94 | 0.07 |
| 2007 | 2100 | 93 | 0.08 |
| 2008 | 2100 | 92 | 0.09 |
| 2009 | 2100 | 91 | 0.10 |
| 2010 | 2100 | 90 | 0.11 |
| 2011 | 2100 | 89 | 0.12 |
| 2012 | 2100 | 88 | 0.13 |
| 2013 | 2100 | 87 | 0.14 |
| 2014 | 2100 | 86 | 0.15 |
| 2015 | 2100 | 85 | 0.16 |
| 2016 | 2100 | 84 | 0.17 |
| 2017 | 2100 | 83 | 0.18 |
| 2018 | 2100 | 82 | 0.19 |
| 2019 | 2100 | 81 | 0.20 |
| 2020 | 2100 | 80 | 0.21 |
| 2021 | 2100 | 79 | 0.22 |
| 2022 | 2100 | 78 | 0.23 |

| | | | |
|---|---|---|---|
| 2023 | 2100 | 77 | 0.24 |
| 2024 | 2100 | 76 | 0.25 |
| 2025 | 2100 | 75 | 0.26 |
| 2026 | 2100 | 74 | 0.27 |
| 2027 | 2100 | 73 | 0.28 |
| 2028 | 2100 | 72 | 0.29 |
| 2029 | 2100 | 71 | 0.30 |
| 2030 | 2100 | 70 | 0.31 |
| 2031 | 2100 | 69 | 0.32 |
| 2032 | 2100 | 68 | 0.33 |
| 2033 | 2100 | 67 | 0.34 |
| 2034 | 2100 | 66 | 0.35 |
| 2035 | 2100 | 65 | 0.36 |
| 2036 | 2100 | 64 | 0.37 |
| 2037 | 2100 | 63 | 0.38 |
| 2038 | 2100 | 62 | 0.39 |
| 2039 | 2100 | 61 | 0.40 |
| 2040 | 2100 | 60 | 0.41 |
| 2041 | 2100 | 59 | 0.42 |
| 2042 | 2100 | 58 | 0.43 |
| 2043 | 2100 | 57 | 0.44 |
| 2044 | 2100 | 56 | 0.45 |
| 2045 | 2100 | 55 | 0.46 |
| 2046 | 2100 | 54 | 0.47 |
| 2047 | 2100 | 53 | 0.48 |
| 2048 | 2100 | 52 | 0.49 |
| 2049 | 2100 | 51 | 0.50 |
| 2050 | 2100 | 50 | 0.51 |
| 2051 | 2100 | 49 | 0.52 |
| 2052 | 2100 | 48 | 0.53 |
| 2053 | 2100 | 47 | 0.54 |
| 2054 | 2100 | 46 | 0.55 |
| 2055 | 2100 | 45 | 0.56 |
| 2056 | 2100 | 44 | 0.57 |
| 2057 | 2100 | 43 | 0.58 |
| 2058 | 2100 | 42 | 0.59 |
| 2059 | 2100 | 41 | 0.60 |
| 2060 | 2100 | 40 | 0.61 |
| 2061 | 2100 | 39 | 0.62 |
| 2062 | 2100 | 38 | 0.63 |
| 2063 | 2100 | 37 | 0.64 |
| 2064 | 2100 | 36 | 0.65 |
| 2065 | 2100 | 35 | 0.66 |
| 2066 | 2100 | 34 | 0.67 |
| 2067 | 2100 | 33 | 0.68 |
| 2068 | 2100 | 32 | 0.69 |

| | | | |
|---|---|---|---|
| 2069 | 2100 | 31 | 0.70 |
| 2070 | 2100 | 30 | 0.71 |
| 2071 | 2100 | 29 | 0.72 |
| 2072 | 2100 | 28 | 0.73 |
| 2073 | 2100 | 27 | 0.74 |
| 2074 | 2100 | 26 | 0.75 |
| 2075 | 2100 | 25 | 0.76 |
| 2076 | 2100 | 24 | 0.77 |
| 2077 | 2100 | 23 | 0.78 |
| 2078 | 2100 | 22 | 0.79 |
| 2079 | 2100 | 21 | 0.80 |
| 2080 | 2100 | 20 | 0.81 |
| 2081 | 2100 | 19 | 0.82 |
| 2082 | 2100 | 18 | 0.83 |
| 2083 | 2100 | 17 | 0.84 |
| 2084 | 2100 | 16 | 0.85 |
| 2085 | 2100 | 15 | 0.86 |
| 2086 | 2100 | 14 | 0.87 |
| 2087 | 2100 | 13 | 0.88 |
| 2088 | 2100 | 12 | 0.89 |
| 2090 | 2100 | 10 | 0.90 |
| 2091 | 2100 | 9 | 0.91 |
| 2092 | 2100 | 8 | 0.92 |
| 2093 | 2100 | 7 | 0.93 |
| 2094 | 2100 | 6 | 0.94 |
| 2095 | 2100 | 5 | 0.95 |
| 2096 | 2100 | 4 | 0.96 |
| 2097 | 2100 | 3 | 0.97 |
| 2098 | 2100 | 2 | 0.98 |
| 2099 | 2100 | 1 | 0.99 |
| 2100 | 2100 | 0 | 1.00 |

**Source:** Researcher’s calculations

## Annexure 2:

**Table 3: Summary of coastal zone management unit hazard risk scores, highest to lowest risk**

| CZMU Code | CZMU Name | SLR Induced Erosion and Inundation | Groundwater Contamination | Extreme Events | Average Risk |
|---|---|---|---|---|---|
| K1 | Sedgefield-Swartvlei | 6.4 | 9.5 | 9.5 | 8.5 |
| G5 | Wilderness East | 8.3 | 6.5 | 9.2 | 8.0 |
| G4 | Wilderness West | 8.3 | 6.5 | 9.2 | 8.0 |
| K6 | Knysna | 6.7 | 7.5 | 9.5 | 7.9 |
| B2 | Plettenberg Bay | 5.8 | 6.7 | 9.6 | 7.4 |
| M5 | Hartenbos | 5.8 | 5.7 | 9.6 | 7.1 |
| B3 | Keurbooms-Bitou | 5.8 | 5.7 | 9.6 | 7.1 |
| B6 | Nature's Valley | 5.7 | 4.8 | 9.6 | 6.7 |
| M6 | Klein-Brakrivier | 5.8 | 5.0 | 8.6 | 6.5 |
| M7 | Groot-Brakrivier | 5.8 | 5.0 | 8.6 | 6.5 |
| K3 | Walker's Bay | 4.8 | 4.8 | 9.6 | 6.4 |
| M4 | Mossel Bay | 5.0 | 4.8 | 8.6 | 6.1 |
| B4 | Keurboomsstrand | 4.3 | 4.3 | 6.7 | 5.1 |
| M8 | Outeniquastrand | 5.0 | 3.6 | 6.7 | 5.1 |
| H4 | Stilbaai | 3.3 | 5.2 | 6.7 | 5.1 |
| K2 | Goukamma | 3.6 | 5.7 | 5.0 | 4.8 |
| M2 | Vleesbaai | 4.2 | 4.2 | 5.7 | 4.7 |
| G6 | Kleinkrantz | 4.3 | 3.6 | 5.8 | 4.6 |
| K4 | Buffelsbaai | 3.6 | 4.3 | 5.0 | 4.3 |
| G1 | Herolds Bay | 2.9 | 3.6 | 5.8 | 4.1 |
| G3 | Victoria Bay | 2.9 | 3.6 | 5.8 | 4.1 |
| H1 | Witsand | 3.3 | 2.8 | 5.8 | 4.0 |
| M1 | Visbaai | 2.9 | 4.2 | 3.8 | 3.6 |
| G2 | George | 2.4 | 5.0 | 3.0 | 3.5 |
| K7 | Noetzie | 2.4 | 3.6 | 4.2 | 3.4 |
| M3 | Pinnacle Point | 2.9 | 3.6 | 3.6 | 3.3 |
| B5 | De Vasselot | 2.9 | 3.6 | 3.6 | 3.3 |
| B7 | Bloukrans | 2.9 | 3.6 | 3.6 | 3.3 |
| H6 | Gouritsmond | 2.6 | 3.6 | 3.3 | 3.2 |
| H5 | Ystervark | 1.9 | 5.2 | 2.2 | 3.1 |
| H3 | Jongensfontein | 2.2 | 3.3 | 3.3 | 3.0 |
| B1 | Sinclair-Robberg | 2.4 | 3.0 | 3.0 | 2.8 |
| G7 | Gericke's Point | 2.4 | 2.4 | 3.3 | 2.7 |
| H2 | Duiwenhoks | 1.9 | 2.8 | 3.2 | 2.6 |
| K5 | Brenton-On-Sea | 1.9 | 3.0 | 2.4 | 2.4 |
| M9 | Maalgate | 1.9 | 2.4 | 2.4 | 2.2 |

***Source:*** *Umvoto Africa, 2010:17*

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